TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

Number Eleven

MEETING OF OCTOBER 11, 12, 13, 14, 1920

DAYTON, OHIO

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Society of
Motion Picture Engineers
New York, N. Y.

RESULT OF ANNUAL ELECTION
OCTOBER, 1920

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THE PAST PRESIDENT

EXTRACTS FROM BY-LAWS

Membership in the Society of Motion Picture Engineers stands for unselfish service to the Industry. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion-picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein and the maintenance of a high professional standing among its members.

Qualifications

Active Member—An Active member shall not be less than 25 years of age and shall be:

(a) A motion picture engineer by profession. He shall have been in the practice of his profession for a period of at least three years and shall have taken responsibility for the design, installation or operation of systems or apparatus pertaining to the motion picture industry.

(b) A person regularly employed in motion picture or closely allied work, who by his inventions or proficiency in motion picture science or as an executive of a motion picture enterprise of large scope, has attained a recognized standing in the motion picture art. In the case of such an executive, the applicant must be qualified to take full charge of the broader features of motion picture engineering involved in the work under his direction.

Associate Member—An Associate member shall not be less than 21 years of age and shall be:

A person who is interested in or connected with the study of motion picture technical problems or the application of the same.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least one member in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

Entrance Fees and Dues

The entrance and transfer fees, payable on admission to the Society, or upon transfer, are as follows: Admission to grade of Active member, $35.00; admission to grade of Associate member, $10.00.

The transfer fee from Associate grade is the difference between the admission fee, or $25.00.

The annual dues are as follows: For Active members, $20.00; for Associate members, $10.00.

LIST OF ACTIVE MEMBERS

Akeley, Carl E.,
Akeley Camera, Inc.,
249 W. 50th St., N. Y. City.

Allison, John W.,
Welanetz Co., Inc.,
Bartholdi Bldg.,
Broadway and 23rd St., N. Y. C.

Anderson, Carl,
21 Douglaston Road,
Douglaston, L. I.

Bassett, Preston R.,
Sperry Gyroscope Co.,
Manhattan Bridge Plaza,
Brooklyn, N. Y.

Bateholts, C. F.,
General Electric Co.,
Schenectady, N. Y.

Beechlyn, J. T.,
General Electric Co.,
Lynn, Mass.

Blair, George A.,
Eastman-Kodak Co.,
Rochester, N. Y.

Bragdon, E. L.,
Motion Picture News,
729 Seventh Ave., N. Y. City.

Braun, Wm. T.,
64 East Van Buren St.,
Chicago, Ill.

Brockett, Paul,
Smithsonian Institute,
Washington, D. C.

Burnap, Robert S.,
Edison Lamp Works,
Harrison, N. J.

Burrows, Robert P.,
823 Prospect Ave.,
Cleveland, Ohio.

Cameron, A. D.,
General Electric Co.,
Schenectady, N. Y.

Cameron, James R.,
Theatre Supply Co.,
124 West 45th St., N. Y. City.

Campe, H. A.,
Westinghouse Elec. & Mfg. Co.,
East Pittsburgh, Pa.

Casler, Herman,
Marvin & Casler Co.,
328 N. Peterboro St.,
Canastota, N. Y.

Cook, Willard B.,
Pathéscope Co.,
Aeolian Hall, N. Y. City.

Cromelin, Paul R.,
Inter-Ocean Film Corp.,
218 West 42nd St., N. Y. City.

Cudmore, H. H.,
Argus Enterprises, Inc.,
815 Prospect Ave.,
Cleveland, Ohio.

Davidson, L. E.,
United Projector and Film Co.,
69 West Mohawk St.,
Buffalo, N. Y.

Dennington, A. R.,
Westinghouse Lamp Co.,
Bloomfield, N. J.

Dwyer, Leo E.,
Dwyer Bros. & Co.,
520 Broadway,
Cincinnati, Ohio.

Egeler, C. E.,
National Lamp Works,
Nela Park, Cleveland, Ohio.

Fox, Wm. Francis,
130 West 46th St., N. Y. City.

Gage, Henry Phelps,
Corning Glass Works,
Corning, N. Y.

Gilman, J. M.,
Dwyer Bros.,
520 Broadway, Cincinnati, O.

Gillett, E. Kendall,
Motion Picture News,
729 Seventh Ave., N. Y. City.

Glover, Harry M. R.,
Gundlach Manhattan Opt'l Co.,
Rochester, N. Y.

Gorretta, Andrew,
Cosmograph Motion Picture Co.,
Morehead, Ky.

Gregory, Carl Louis,
76 Echo Ave.,
New Rochelle, N. Y.

Grierson, Major R.,
82 Wardour Street,
London, England.

Halverson, C. A. B.,
General Electric Co.,
West Lynn, Mass.

Hastings, R. G.,
Motion Picture Apparatus Co.,
New York City.

Hertner, J. H.,
Hertner Electric Co.,
1906 West 114th St.,
Cleveland, Ohio.

Hochstetter, F. W.,
P. O. Box 895, Dayton, O.

Howell, A. S.,
1801 Larchmont Ave.,
Chicago, Ill.

Hubbard, Wm. C.,
Cooper-Hewitt Electric Co.,
120 Broadway, N. Y. City.

Jenkins, C. Francis,
5502 Sixteenth St., N.W.
Washington, D. C.

Johnson, M. Bernays,
Westinghouse Lamp Co.,
Bloomfield, N. J.

Jones, L. A.,
Eastman-Kodak Co.,
Rochester, N. Y.

Kelley, Wm. V. D.,
Prizma, Inc.,
71 West 23rd St., N. Y. City.

Kellner, Dr. Herman,
Bausch & Lomb Optical Co.,
Rochester, N. Y.

Kessel, N.,
Main St. and Linwood Ave.,
Fort Lee, N. J.

Kroesen, J. C.,
Edison Lamp Works,
Harrison, N. J.

Kunzman, Wm. C.,
National Carbon Co.,
Box 400, Cleveland, Ohio.

Lair, C.,
Pathé Cinema,
Vincennes, France.

Lang, C. J.,
Lang Mfg. Co.,
Olean, N. Y.

Lee, R. L.,
Delco Light Co.,
Dayton, Ohio.

Little, W. F.,
Electrical Testing Laboratories,
80th St. and East End Ave.,
New York, N. Y.

MacNary, H. C.,
Westinghouse Elec. & Mfg. Co.,
165 Broadway, N. Y. City.

Manheimer, J. R.,
E-J Electrical Installation Co.,
221 West 32nd St., N. Y. City.

Mayer, Max,
M. J. Wohl & Co., Inc.,
Payntar Ave.,
Long Island City, N. Y.

McNabb, J. H.,
1801 Larchmont Ave.,
Chicago, Ill.

Morrison, E.,
Barr & Stroud, Ltd.,
15 Victoria St.,
London, S.W. 1, England.

Mott, W. R.,
National Carbon Company,
Cleveland, Ohio.

Moulton, J. C.,
General Electric Co.,
120 Broadway, N. Y. City.

Murphy, E. F.,
Universal Film Mfg. Co.,
Fort Lee, N. J.

Nelson, Wm. E.,
Wilart Instrument Co.,
13 Rose St., New Rochelle, N. Y.

Norrish, B. E.,
Canadian Pacific Rwy.,
Windsor Station,
Montreal, Canada.

O'Brien, Harold F.,
Westinghouse Elec. & Mfg. Co.,
811 Van Nuys Bldg.,
Los Angeles, Cal.

Palmer, M. W.,
Famous Players-Lasky Corp.,
Long Island City, N. Y.

Perkins, George F.,
497 Phillips Square,
Montreal, Canada.

Porter, Edwin S.,
Precision Machine Co.,
317 East 34th St., N. Y. City.

Porter, E. M.,
317 East 34th St., N. Y. City.

Porter, Lawrence C.,
Edison Lamp Works,
Fifth and Sussex Sts.,
Harrison, N. J.

Proctor, B. R.,
618 West 114th St., N. Y. City.

Quinlan, Walter,
Fox Film Corp.,
55th St. and 10th Ave.,
New York City.

Rabell, Wm. H.,
729 Seventh Ave., N. Y. City.

Redpath, Wm.,
156 King St., W.,
Toronto, Canada.

Rembusch, Frank,
Rembusch Screen Co.,
Shelbyville, Indiana.

Richards, Thomas T.,
Wagner Elec. Mfg. Co.,
6400 Plymouth Ave.,
St. Louis, Mo.

Richardson, Frank H.,
Moving Picture World.
516 Fifth Ave., N. Y. City.

Roebuck, A. C.,
Enterprise Optical Co.,
564 West Randolph St.,
Chicago, Ill.

Rose, S. G.,
Victor Animatograph Co.,
Davenport, Iowa.

Rossman, Earl W.,
609 W. 127th St.,
New York City.

Rothacker, W. R.,
Rothacker Film Mfg. Co.,
1339 Diversey Parkway,
Chicago, Ill.

Speer, J. S.,
Speer Carbon Co.,
St. Marys, Pa.

Smith, Will C.,
Nicholas Power Co., Inc.,
90 Gold St., N. Y. City.

States, Wm. M.,
International Gen. Elec. Co.,
Box 926, Shanghai, China.

Story, Dr. W. E., Jr.,
General Electric Company,
Schenectady, N. Y.

Summers, John A.,
Edison Lamp Works,
Harrison, N. J.

Turner, H. H.,
Gundlach Manhattan Opt'l Co.,
Rochester, N. Y.

Urban, Charles,
71 West 23rd St., N. Y. City.

Victor, A. F.,
50 W. 67th St., N. Y. City.

Westcott, W. B.,
Technicolor Motion Pict. Corp.,
110 Brookline Ave.,
Boston, Mass.

Wible, Harvey M.,
Westinghouse Elec. & Mfg. Co.,
Supply Dept., Newark, N. J.

Wollensack, Andrew,
Wollensack Optical Co.,
Rochester, N. Y.

Ziebarth, C. A.,
Bell & Howell Co.,
1801 Larchmont Ave.,
Chicago, Ill.

List of Associate Members

Clarke, Victor A.,
Famous Players-Lasky Corp.,
Long Island City, N. Y.

Dutton, H. A. R.,
845 South Wabash Ave.,
Chicago, Ill.

Gage, Otis Amsden,
Corning Glass Wks.,
Corning, N. Y.

Gilbert, Frank J.,
National Cash Register Co.,
Dayton, Ohio.

Hornstein, J.,
Howell Cine Equipment Co.,
729 Seventh Ave., N. Y. City.

Kraemer, August,
Famous Players-Lasky Corp.,
Long Island City, N. Y.

Ladd, W. P.,
Perkins Electric Co.,
Montreal, Canada.

McGinnis, F. J.,
Spear Carbon Co.,
St. Marys, Pa.

Nelson, Otto,
Dales & Hills,
Dayton, Ohio.

Nixon, Ivan L.,
Bausch & Lomb Optical Co.,
Rochester, N. Y.

Ohmer, W. I.,
Record'g & Comput'g Mach. Co.,
Dayton, Ohio.

Perkins, E. G.,
704 Dollar Bank Bldg.,
Youngstown, Ohio.

Rohr, C. A.,
General Electric Co.,
120 Broadway, N. Y. City.

Stevenson, A. R., Jr.,
General Electric Co.,
Schenectady, N. Y.

LISTS OF VARIOUS COMMITTEES—1920-1921
Society of Motion Picture Engineers

Electric Devices Committee

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R. L. Lee
A. R. Dennington
J. H. Hertner
W. C. Kunzman
Max Meyer
J. S. Speer
E. L. Bragdon
C. A. B. Halvorson
A. D. Cameron
J. R. Manheimer
H. F. O'Brien
P. R. Bassett
W. C. Hubbard

Projection Machines Committee

W. C. Smith, *Chairman*

A. C. Roebuck
W. B. Cook
F. H. Richardson
C. F. Jenkins
E. M. Porter
A. F. Victor
Herman Casler
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B. R. Proctor
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R. P. Burrows
H. C. MacNary
E. L. Bragdon

Safety Committee

A. F. Victor, *Chairman*

J. C. Moulton
G. A. Blair

A. D. Cameron, *Chairman*

Frank Rembusch
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Optics Committee

W. E. Story, *Chairman*

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R. S. Burnap
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W. R. Rothacker
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R. L. Lee
W. C. Kunzman
G. A. Blair
G. F. Perkins
H. H. Cudmore
W. C. Hubbard
F. H. Richardson
W. C. Smith
R. Grierson

Cameras and Perforations Committee

W. B. Cook, *Chairman*

Carl Gregory
Carl Akeley
A. S. Howell
C. F. Jenkins

Reciprocal Relations

R. P. Burrows, *Chairman*

Herman Kellner
W. B. Cook

PRESIDENT'S ADDRESS

ANY doubts as to the success of the Society of Motion Picture Engineers has long since been dispelled. The period since the organization of our Society has been a trying one. Dark clouds have loomed on the horizon of our vision, but these have disappeared and our future now looks exceedingly bright. We have just completed our fourth year and we look optimistically to the future.

If you will permit me, I shall say a few words with reference to our membership. The Society began in the Fall of 1916 with approximately 25 members. Of this number, 18 are still on the roll and in good standing. Since then, our membership has increased until it now has a total of 78 members, notwithstanding quite a number of members have dropped out through resignation or other causes.

You, by your action at the Montreal meeting, authorized the formation of an Associate Membership classification. This is going to be a considerable help to the Society in furthering its important work. We must be judicious, however, in increasing our membership and see that only those fully entitled to membership are enrolled.

Closely related to the matter of membership is the question of attendance at our meetings. In order to be a useful member, you should regularly attend the meetings. A careful analysis shows that a little group of faithful members attend regularly, but the greater number attend only irregularly or not at all. We should aim to have a 100% attendance at each meeting. It is the endeavor to make the meetings as instructive and interesting as possible and to this end, your officials have been both active and solicitous.

I have frequently and consistently pointed out at previous meetings, the fact that the backbone of our Society should be and is, the result of the work of our Standing Committees. Some of our Committees have done commendable work, others have only worked half-heartedly, while others have merely reported progress. In an industry such as the motion picture industry, there are so many developments and changes, that without question, each Committee should have a full and detailed report, at least once a year. The Society will forge ahead only in proportion to the constructive activities of its various Committees.

The program for this meeting is certainly attractive. The Committee on Arrangements has been untiring in its efforts to make this the best meeting which we have ever held and I am sure that these efforts will be effective. Unquestionably, each of you will leave Dayton with the thought that Dayton is a most hospitable city, that we have had a splendid meeting and that it is not a small honor to be a member of the Society of Motion Picture Engineers.

At this time, I desire to express the appreciation of the Society to those who have made our success possible. This includes, espe-

cially, the officers who willingly served without any compensation whatever, as well as the members of the Committee on Papers and Committee on Publication. It is, by no means, an easy matter to formulate a program. The Committee on Papers has to keep continually after the authors on the matter of preparing papers and, further, it has to see that all promises given are kept. After the papers have been accepted and presented, there is considerable work by the Committee on Papers and Committee on Publication in collecting illustrations, having cuts made, reading of proofs, and arranging for the final printing. A careful analysis of the proceedings of our Montreal meeting, a book of 105 pages, should indicate to you, in a measure, the ground that these Committees have had to cover. Let us show our appreciation of their efforts. The members and others who prepare papers for our program should also receive our appreciation. The preparation of these papers is not a matter of days: it means the presentation of facts, gathered from a fund of data and experience, so grouped as to become easily understood.

Your Board of Governors has regularly met once and sometimes oftener between stated meetings, for the purpose of carrying on and planning the Society's business.

At this, the close of my administration as your President, I want to, personally, thank the officers and members of the Society for the loyal and unselfish support with which I have been encouraged and sustained. Each of you has contributed his part to any efficiency I may have displayed, and as to my short comings, I trust you may overlook them—except as they may serve as danger signals to my successor—recalling only those things in which I may have proved constructive and helpful in leadership.

As we have such an excellent program ahead of us for the next four days I will not burden you further. The meeting is now yours.

H. A. CAMPE, *President.*

Extracts from

MINUTES OF THE FIFTH ANNUAL MEETING

of the

SOCIETY OF MOTION PICTURE ENGINEERS

Held at the

MIAMI HOTEL, DAYTON, OHIO

October 11, 12, 13, 14, 1920

Monday Morning, October 11th, 1920.

Minutes of the meeting of the Board of Governors, held in New York City on July 19, 1920, and Dayton, October 10, 1920, were read by the Secretary, and approved.

The following new members were elected, and the names read by the Secretary:

Mr. M. Burnays Johnson
Mr. Preston R. Fassett
Mr. Joe Hornstein
Mr. Ivan L. Nixon
Mr. H. A. R. Dutton
Mr. Francis J. McGinnis
Mr. I. V. Hochstetter
Mr. E. G. Perkins

The question of price to be established on the Transactions printed by the Society was brought up and an animated discussion followed.

After careful consideration the following motion was made, seconded and carried.

Motion: That the Transactions up to, but not including, the Pittsburgh meeting be sold as formerly, at $.25 each, and that the price thereafter be $1 each.

The Secretary was instructed to secure prices on binding the four Transactions consisting of the Philadelphia, Pittsburgh, Montreal and Dayton meetings, and that he notify all members of such cost, and have bound up a number of copies, if a sufficient call for them was received.

Luncheon was held at the Engineers' Club, during which the Hon. J. M. Switzer, Mayor of Dayton, welcomed the members to the City, and to which response was made by Past President, Mr. C. F. Jenkins.

ELECTION OF OFFICERS.

Report by the nominating committee was read by W. B. Cook, Chairman.

The following officers were elected by written ballot:

President ..... H. A. Campe
Vice-President ..... Robert P. Burrows
Secretary ..... A. F. Victor
Treasurer ..... W. E. Smith
Board of Governors..W. B. Cook, L. C. Porter

The election of officers was followed by a paper "History of Motion Pictures," by Mr. C. F. Jenkins.

Mr. A. F. Victor desired to know whether Dr. Goodwin or Carbutt was the real inventor of celluloid.

Both Mr. Jenkins and Mr. Blair stated that Dr. Goodwin was undoubtedly the real inventor.

Report of the Safety Committee was read by Mr. A. F. Victor, Chairman.

Mr. Carl Gregory being absent and his paper not being available, the President requested that Dr. Kellner present his report.

Demonstration and Discussion by Optics Committee.

A discussion followed the report in which Dr. W. E. Storey, Mr. H. P. Gage, Mr. F. W. Little, Mr. I. V. Hochstetter, and Dr. Herman Kellner participated.

Report of Committee on Cameras by Mr. Willard B. Cook, Chairman.

Mr. Cook reported that a new book on "Condensed Course in Motion Picture Photography" had recently been written by Mr. Carl Gregory, a member of the Committee on Cameras, and was now available.

Report from Membership Committee, Mr. A. C. Roebuck, Chairman.

After the report had been read the committee was complimented by the chairman for its splendid activities and the good work whereby the Society had been brought to a membership of over one hundred.

Report from Committee on Advertising, presented by Mr. R. P. Burrows, Chairman.

It was moved, seconded and carried that the first resolution embodied in the report of Mr. Burrow be accepted.

It was moved, seconded and carried that the second resolution embodied in the report of Mr. Burrows be accepted.

A paper was then presented by Mr. G. A. Blair on "Reducing Fire Hazards in Film Exchanges."

Discussion.

Mr. Blair added, after reading his paper, that the Eastman Kodak Company was now extending its work to the actual projection rooms and attempting to educate the projectionists of the country as to the hazards of the material handled by them.

Mr. Campe said that the paper clearly showed the cooperative efforts between many factions to bring about safety.

Mr. Manheimer asked for further details regarding the Kansas City fire referred to in Mr. Blair's paper.

Mr. Blair stated that he was certain that if the fire extinguishers had been installed at the time the fire occurred, they would have easily placed the fire under control, but said that unfortunately the automattic sprinkler system was under construction and not ready to operate at the time of the fire.

Mr. Bernays Johnson said that he had been present during one of the lectures given by the Eastman Kodak Company to Projectionists, but had failed to obtain specific information as to proper methods whereby film fires might be extinguished.

Mr. Blair replied that while he was not in the fire extinguisher business, he considered that water was the best medium for the purpose and that it served to put out fires chiefly due to its cooling action.

Mr. Johnson desired to know whether film was explosive.

Mr. Blair said that it was not explosive if in the open, but only confined in places where the correct mixture of air might be the means of causing an explosion.

Mr. Jenkins desired to know whether the connecting of the upper magazine with the open air would prevent explosions, and also desired to know whether Mr. Blair would recommend the sprinkler system in projection rooms.

Mr. Blair said that he would recommend sprinkler systems in all projection rooms.

Mr. Smith said that his experience had convinced him that most fires occurring in projection booths were due to lack of knowledge on the part of the projectionists. He also stated that if the fire valves in the magazine were kept clean, and, if the projectionist, when a fire occurred to the exposed film, would merely step back from the machine and allow the fire to burn itself out, the safety devices of the projector would automatically smother the fire and no damage would occur.

Mr. Johnson called attention to the possibility of pieces of burning film being dragged through the valves and in their turn setting fire to the reels within the magazines. He again stated that what the projectionists wanted to know is what to do in the case of a fire, and said that he considered they did all they could to keep from having one, but that it would be of advantage if they are instructed how to stop a fire after it had once started.

Mr. Manheimer said that from his experience he was certain that water was the superior medium whereby to put out film fires.

Mr. F. J. McGinnis related a case in which the fire had jumped into the magazine after having ignited some film collected around the top sprocket. He said the projectionist was experienced, but had never had a film fire before, and foolishly opened the upper magazine. The film, composed of a two thousand foot reel, was burning briskly on the floor, and the projectionist seemed unable to

think of something to do, but he (McGinnis) put out the fire very quickly by the aid of a fire extinguisher, and therefore felt certain that if a fire extinguisher was properly used it would serve to put out film fires.

Mr. Smith stated that he knew of the fire in question; that the film was imperfect and that sprocket backed the film up against the magazines, and that no serious fire would have occurred if the magazine door had been left closed.

Mr. C. J. Lang added to the previous remarks the statement that in the fire in question there was about nine inches of film leading from the aperture to the magazine which did not ignite. This proved to be quite a mystery and a number of suggestions were made as to how this had proved possible.

Mr. Campe now called upon Mr. Lee to address the members.

Mr. Lee, after expressing his gratification over the fact that so many members had come to Dayton to attend the meeting, asked that the Society make itself at home while visiting there and said that the Engineers' Club and everything within its walls were at their disposal. He further said that members should not fail to hear Mr. Kettering's address to be made during the dinner scheduled at 6.15 in the evening.

Dinner was given at the Engineers' Club during which the members were addressed by Mr. C. F. Kettering, Chief Engineer of the General Motors Corporation.

His address was a memorable event to the Society, and the Secretary cannot avoid putting in these minutes his own and his fellow members' expression of appreciation.

Tuesday Morning, October 12th, 1920.

Meeting was called to order at 10 A. M.

Telegrams from absent members were read by the Secretary.

A telegraphic invitation from Mr. C. W. Detz, Chairman, Invitation Committee, of Managers and Projectionists, to attend a banquet held at Hamilton, Ohio, in honor of Mr. Richardson, was received and read by the Secretary.

The Secretary was instructed to reply by telegraph and express the Society's appreciation for the courtesy shown.

A paper and discussion, "Power Plant and Electrical Distribution Equipment of New Eastern Studios and Laboratories of the Famous Players-Lasky and Fox Film Corporations," presented by Mr. J. R. Manheimer.

A discussion followed the reading of Mr. Manheimer's paper.

Mr. Burrows, acting chairman during Mr. Campe's absence, said that it was the first paper of the kind presented and felt certain that the paper warranted discussion.

Mr. Richardson desired to know if the bus-bars recommended by Mr. Manheimer in his paper would not deteriorate if overloaded.

Mr. Manheimer explained a system of installing additional units in cases of necessity for greater carrying capacity, and also stated that the bus-bars were vastly superior to cables due to the fact that

they would stand a tremendous overload without causing any trouble even if the overload was such as to render the bus-bars red hot.

Mr. O'Brien said that there appeared to be no protection for each individual bus-bar at the point where it left the main switch. He asked the capacity of individual remote control switches and whether means to take care of expansion and contraction had been taken care of.

Mr. Manheimer said that expansion and contraction of bus-bars, both lateral and vertical had been provided for.

Mr. MacNary called attention to the possibility of different directors using different quantities of light at their work, rendering impossible the acceptance of calculation based upon candle foot illumination in studios. He also called attention to the high cost of installing the system advocated.

Mr. Manheimer agreed that the criticism made by Mr. O'Brien as to the expense of overhead systems was correct, but that the overhead structure was also usable for the fastening of scenery, etc., and therefore had additional advantages making up for the high cost.

Mr. Hubbard said that if future progress would be based upon developments made in the past two years in overhead systems, we may expect some wonderful progress during the next few years.

Mr. Campe informed us that greater advance had been made in studio lighting than any other branch of the industry during the same period of time.

Mr. Manheimer summed up the arguments advanced, and further discussion was referred to the Papers Committee.

REPORT FROM COMMITTEE ON PUBLICATIONS presented by Mr. Bragdon.

Mr. Jenkins suggested that hereafter the lists of committee members be printed in the Transactions.

Mr. Smith suggested that the names and addresses of all members be printed in the Transactions.

This matter was put to a vote and was seconded and carried and the work was referred to the publication committee for action.

REPORT BY PAPERS COMMITTEE presented by Mr. L. C. Porter, Chairman.

The methods advocated by Mr. Porter met with favor and a motion was made, seconded and carried that all of the recommendations offered in the report be accepted and acted upon.

Mr. Porter asked for suggestions from members which might help in obtaining suggestions for papers.

Mr. Jenkins recommended that a paper on the actual making of pictures in studios be prepared.

Mr. McGinnis said that a paper on correct screen angle and the overcoming of Keystone effects was needed.

TREASURER'S REPORT presented by Mr. Will C. Smith.

REPORT OF AUDITING COMMITTEE presented by Mr. Kunzman.

REPORT OF NOMENCLATURE COMMITTEE, Mr. C. F. Jenkins, Chairman.

Mr. Jenkins stated that no report would be presented at this time, owing to the fact that no new developments had occurred.

Mr. Richardson requested a discussion on the standards as published in the Montreal Transactions.

This suggestion was put to vote and it was decided to discuss the matter.

Mr. Richardson called attention to a number of errors and terms in the nomenclature list as published in the Montreal Transactions. He claimed that as printed the terms employed were entirely at variance with established usage by him and other writers.

Mr. Perkins suggested that the list for nomenclature be referred to some new committee for correction.

Mr. Jenkins stated that no terms had been adopted without authorities first having been consulted in the matter, and he thought that the difference of opinion between Mr. Richardson and himself might be due to the fact that one thing may sometimes be called by two different names.

Dr. Kellner desired to know when such a word as optience should be used. He wanted to know when an audience ceased to be an audience and when it commenced to be an optience. Since there would be both music and pictures he had some difficulty in deciding whether he was one or the other.

Mr. Porter explaining how it came about that the cut of the standard theatre film did not appear in the Montreal transactions. It was due to an oversight.

Mr. O'Brien suggested that a committee be appointed at this meeting to take action on the subject.

Mr. Victor made a motion that a committee be appointed to separate the list of nomenclature into its different branches, and that these lists be referred to the committees dealing with that particular subject and then referred back to the nomenclature committee.

The motion was seconded and unanimously carried.

Mr. L. C. Porter desired to make the following amendment to the motion made by Mr. Victor; that any terms, standards, or recommendations proposed by the nomenclature committee be submitted to the Society as a whole at the next convention for consideration, and that final decision be delayed until the next succeeding convention, at which time an approval or rejection by the entire body shall be made.

This amendment was seconded and carried.

REPORT OF COMMITTEE ON PROGRESS presented by Mr. Dennington, Chairman.

Meeting was called to order at 10.30 Wednesday, October 13, by President Campe, at the N. C. R. Schoolhouse.

Paper by Mr. P. R. Bassett "THE HIGH POWER ARC IN SPERRY AUTOMATIC PROJECTOR" was presented.

After the reading of the paper Mr. Campe announced that Mr. Patterson of The National Cash Register Company would address the members.

A discussion followed the reading of the paper participated in by Mr. B. M. Johnson, Mr. P. R. Bassett, Mr. C. A. B. Halvorson, Dr. Mott, Dr. W. E. Storey, Mr. C. F. Jenkins and Mr. W. E. Kunzman.

Mr. Farley in charge of the lecture department of the National Cash Register Company, addressed the members and explained the multitudinous use of motion pictures in connection with the sale of cash registers.

Slides and pictures were shown and diagrams were traced upon ground glass and projected. The address proved extremely interesting and gave the members an idea of the commercial application of pictures as employed in the work of the N. C. R.

A paper was presented by Mr. F. W. Hockstetter entitled "A New Process of Taking Motion Pictures on Opaque Paper Film" and "Method of Illumination Excluding Thermal Rays."

Mr. Hockstetter announced that he was unable to give a demonstration but those interested should visit his laboratories and see the apparatus referred to in operation.

Mr. Manheimer desired to know the capacity of the magazines in connection with the camera spoken of in Mr. Hockstetter's paper.

Mr. Hockstetter said that the camera would be able to take from one to two hundred feet and the projector from two hundred to five hundred feet.

Mr. Hockstetter did not offer substantial proof of his statements but said that he would be able to do so at a later date when his patent would permit him to do so.

Many members expressed admiration for the work while others were skeptical as to the correct data and questioned the possibility of excluding thermal rays by the methods advanced.

Report of Optics Committee.

"Effect of Color on Motion Pictures" and "Absorption and Reflection Losses in Motion Picture Objectives," presented by Dr. Storey.

Mr. Victor desired to know whether, in Dr. Storey's opinion, the variation of opinions was not based upon color blindness frequently encountered in the eyes of people.

Dr. Storey did not think that the variations of opinion were due to color blindness.

Mr. Porter said that owing to the difficulty of determining the effect on different people it would be impossible to establish a standard for practical purposes.

He further said that, in his estimation, the work of the Optics Committee in dealing with the subject had been carried as far as possible; that the data so far obtained should be printed in the

Transactions and be carried on to a further point at a more convenient time.

Mr. Roebuck expressed his opinion that the two images were too widely separated to give the best opportunity for observation.

Mr. Campe stated that we all realized the splendid work done by the Optics Committee, and that the work was appreciated.

The balance of the session was devoted to a trip through the plant of the National Cash Register Company, which included a luncheon at the N. C. R. Officers' Club Dining Room.

The trip through the National Cash Register factory was followed by a trip to Morain City, the location of Research Laboratories of the General Motors Corporation.

A banquet was given at the Engineers' Club in the evening at 6.30.

During the banquet an address by Col. Deeds proved one of the events of the Society's visit in Dayton.

Col. Deeds related some very interesting incidents from his trips through the battle fields of Europe.

His sympathetic attitude toward the efforts of the engineers today awakened a responsive chord and gave a great deal of encouragement and inspiration to us all.

Thursday, October 14th, 1920.

Meeting called to order by the President at 10 A. M.

Mr. Beusch of the N. C. R. expressed his gratification over the selection by the S. M. P. E. in coming to Dayton, and, on behalf of Mr. Patterson, welcomed us. He expressed Mr. Patterson's great regret in not being able to personally greet us, as he had hoped to do.

A paper "PORTABLE GENERATING EQUIPMENT" was presented by Mr. F. O'Brien.

Discussion followed Mr. O'Brien's paper, during which Mr. Hertner desired to know if the type of carburetor mentioned in Mr. O'Brien's paper employed heavy oil or gasoline.

Mr. O'Brien said that both could be used but that on the coast gasoline was used exclusively, chiefly on account of the expense of the apparatus, gasoline being less damaging to the machines.

REPORT OF ELECTRICAL DEVICES COMMITTEE.

Read by Mr. Roebuck during the absence of Mr. Wible, Chairman.

REPORT OF THE PROJECTION MACHINE COMMITTEE, presented by Mr. W. C. Smith, Chairman.

REPORT OF THE CORRESPONDENCE COURSE COMMITTEE, presented by A. R. Dennington.

Mr. Victor said that in his opinion the task was beyond the Society, both financially and otherwise and suggested that the matter be definitely dropped.

Mr. Porter remarked that credit for the preparation of the report was due to Mr. Dennington.

Mr. McGinnis cited an attempt made by another organization of which he was a member to establish a correspondence course. He said that he did not question the ability of our Society to produce perfect projectionists by means of correspondence, but called attention to the fact that local requirements where in some cases an apprentice was compelled to put in six months actual work before permitted to operate a projector, would work against the scheme. He said that he agreed with Mr. Victor that the matter be dropped.

Mr. Burrows said that it had been hoped at the time the plan for a correspondence course was proposed, that we would be able to be of assistance to the projectionists, but if, as appeared to be the case, the projectionists would be narrow-minded enough to be antagonistic to the scheme, and if, in addition, the plan was financially impractical, he offered as an alternative that the Society make an offer of assistance to some existing correspondence schools, for instance, the one operated in Scranton.

Mr. Bragdon suggested that by increasing the edition from a suggested 5,000 to 10,000 the cost per copy would be lowered and wondered if this would prove a way out of the difficulty.

Mr. Jenkins stated that he considered the remarks made had very well covered the subject and considered that the difficulties confronting the Society in carrying out its plans were such as to prevent the undertaking of the work.

Mr. Porter, in order to refresh our memory of the recommendation made at the Montreal meeting, read it and said that it might not be practical of the Society to handle the financial end, but that some way might be devised in which our technical knowledge might be at the disposal of the projectionists.

Mr. Cameron said that two correspondence schools already had courses for projectionists.

Mr. Perkins mentioned that in conversation with a member of the La Salle Institute he (the member) had expressed as his opinion that the Institute would be glad to handle the work if the Society would sponsor the matter.

It was moved, seconded and carried that the report be referred back to the Special Committee for further consideration.

Paper on "CHARACTERISTICS OF MOTION PICTURE SCREENS," by Mr. L. A. Jones.

A discussion followed Mr. Jones' paper.

Mr. Egeler said that the work done by his organization checked very well with Mr. Jones' data. He said that his observation had been that the Keystone effect and placing of screens also called for vertical, as well as horizontal consideration. He asked if Mr. Jones had considered the vertical problem.

Mr. Jones replied that the examination of screens made by him had considered both vertical as well as horizontal questions.

Mr. Victor said that the paper was a "peach" and that here

possible to formulate data whereby screens of given numbers could be obtained for theatres having definite angle requirements.

Mr. Smith stated that Mr. Victor had expressed exactly what was in his mind.

Mr. Rembusch said that he was very much interested in Mr. Jones' paper. He stated that the first mirror screens were manufactured by him and were made for narrow theatres, but that the same screen, if placed at the proper distance from the front rows, would serve for wide theatres. He wanted to know if Mr. Jones had considered the colored screens. He said that a white screen was preferable on account of giving correct color values to tinted and toned films. He gave a description of the effect of various mirror screens and methods of coating surface of such to cause diffusion in making mirror screens practical for wide angle observation.

Mr. Porter wanted to know if the figure obtained from flat screens could also be applied to the concave type.

Mr. Jones said that color had not been considered in his observation. He said that he personally preferred a tinted screen and hoped to obtain data on such screens at a later date. He recommended that the Society decide upon a definite measure of screen illumination, or, at least, a definite limit beyond which we should not go.

It was moved, seconded and unanimously carried that a vote of thanks be given to the following Dayton organizations for the courtesy extended to the S. M. P. E. during its visit as well as the encouragement and inspiration given to our work while in that city:

Delco Light Company,
Delco Company,
National Cash Register Company,
General Motors Corporation,
Engineers' Club of Dayton,
Miami Hotel, Mr. Smith and their assistants, and the Secretary be instructed to write a letter of appreciation to each organization.

The President now requested that places for our next meeting be suggested.

It was moved, seconded and carried that the next meeting place be selected by means of a ballot.

While the ballot was being taken a report from the SUSTAINING MEMBERSHIP COMMITTEE was rendered by Mr. Cudmore, Chairman.

Mr. Cudmore said that a number of letters had been sent out and that plenty of replies had been received, but that no practical result had been attained. He felt that the method tried would not produce the personnel desired, and that it required the efforts of the entire Society to obtain such members as are truly desirable. He made the suggestion that every member make it his business to pick out the men wanted and send the names to him (Mr. Cudmore) or someone else acquainted with the person suggested. A personal interview should then be arranged with the prospect. He placed the matter before the Board of Governors for their consideration and

said that he felt certain that financial support could be obtained by the method suggested. An additional suggestion made by Mr. Cudmore was that a chapter of the Society be formed in California.

Mr. Campe considered Mr. Cudmore's remarks well made and said the suggestions would be considered by the Board of Governors.

Upon counting the ballots it was found that Washington had been selected with Los Angeles a close second.

The meeting was therefore adjourned until the next convention to be held in Washington some time in April, 1921.

A. F. VICTOR, *Secretary S. M. P. E.*

Report of the Advertising Committee

OUR committee takes pleasure in calling your attention to the advertising appearing in the Montreal Transactions of our society. The class of advertising and the amount speaks well of the co-operation of our individual members and your committee takes this opportunity of expressing their appreciation of the prompt response from the manufacturers who are represented in this advertising.

The advertising for the year 1920 will increase the income of the society by the amount of $855.00, and we sincerely hope that the compensation to the advertisers will be in like proportion.

Your committee has made no attempt to obtain further advertising for the Dayton Transactions for the reason that they thought it best to see how their first venture in advertising was taken.

Your committee would recommend two general subjects for your consideration, and for the consideration of the new Advertising Committee.

The first recommendation is that a concerted effort be made by individuals in the society to obtain advertising from the producers, and to obtain more diversified advertising from the manufacturers represented in the society and those not represented.

The second recommendation is that our rate classification be revised. This revision to include, first, increased return for preferred space such as space next to reading matter, and the last page of advertising; the second being a differential in price between those companies represented by membership and those companies not represented by membership.

Our present price for advertising space is a quarter page in two issues $25.00, one-half page $35.00 for two issues, and a full page $50.00 for two issues. The committee would recommend that the last page of advertising be sold as a full page for two issues at a price of $85.00 and that the page next to reading matter be sold as a full page at a price of $85.00 for two issues, the inside pages to remain the same price. Your committee would further recommend that an increase in the advertising rate of 10% be assessed against those companies wishing to advertise but which have no representative in our membership. Your committee would further recommend that those companies who have representation in the society be given first choice of preferred space.

For the purpose of action your committee presents the following resolutions:

Whereas there are certain advantages in obtaining certain space in our Transactions for advertising, and

Whereas the society believes its membership should have an advantage over non-members in advertising rates, and

Whereas there are certain points as regards collection which have not been covered heretofore, be it resolved:

First, that our advertising rates to companies having representatives as members of the society be as follows:

Quarter page for two issues $25.00. Half page for two issues $35.00. Full page for two issues $50.00. The last page of advertising, full page, two issues $85.00. Page next to reading matter, full page two issues, $85.00.

Second, that those companies not represented by membership in this society wishing to advertise in the Transactions of the society may do so at a rate 10% above prices quoted, it being understood that companies having a representative member shall have first choice of preferred space.

Third, that the chairman of the Advertising Committee shall at the time the forms for advertising close for each issue, advise the Treasurer of the society of those advertising, the amount of space taken, and the total amount due for the two issues; and further, that the Treasurer shall send out a notice covering half the amount due for advertising at the time each of the two issues is mailed, and further that with these invoices should be attached one copy of the Transactions to go to the advertisers.

Your committee offers the following resolution for your consideration:

Whereas a sustaining member of the society is privileged to one page of advertising for the two issues of the year of sustaining membership, and

Whereas there is a special rate for preferred space,

Be it resolved, that space available for the sustaining members shall be interior pages, and further that should sustaining members desire preferred space, such space may be obtained by a payment of $35.00 in addition to sustaining membership fee of $100.00.

R. P. BURROWS, *Chairman.*

REPORT OF COMMITTEE ON PROGRESS

DURING the period since the last meeting of this Society, there has been progress along several lines of the motion picture industry. The condition of any line of activity is reflected, to a great extent, in the improvement in materials, methods and equipment entering into the product. If a comprehensive report of these improvements is made, it is a measure of the growth and development of the industry as a whole. The report presented is, we fear, more or less incomplete, and in this respect it fails as a true indicator of the scope of the work coming within the field of interest of the Society of Motion Picture Engineers.

Projectors:

Among the improvements in standard projectors may be mentioned the use of a pilot lamp or trimming lamp in the lamp house, controlled by a door-switch. When the door of the lamp house is closed, the pilot lamp is out, but as soon as the door is opened for replacing or adjusting carbons the lamp is lighted.

The window in the lamp house door for observing the arc, has been changed into a pin hole camera so that an image of the arc is shown on a piece of ground glass. The new device fits into the holder for the old style glass.

The operation of two machines in a projection room is being made much more convenient than heretofore by the addition of double control handles. These double handles permit the projectionist to control easily the machine at his right.

The spot is also shielded by a double shield which protects the eyes of the projectionist on either side of the machine.

An improved fire guard has been developed for the film gate, which limits the burning of film to a single frame when left in the beam of light.

One manufacturer has made an improvement in the intermittent movement by the use of sleeves or rollers on the pins engaging with the cam thus providing rolling friction in place of sliding friction. The rollers are held in place by a plate on the back of the cam.

A portable projector with a solid bakelite case in place of the usual leather-covered metal case, has been placed on the market. This provides a light weight, fire-resisting construction of good appearance.

Right Angle, Automatic Projection Arc.

With the idea in mind of increasing the general illuminating efficiency of the projection arc, a right angle, high intensity arc lamp has been perfected. This lamp employs a positive carbon rotated by a motor and a magnetic circuit which automatically feeds the

negative. The positive carbon lies horizontally along the optical axis and the negative electrode is so placed as to direct the light rays straight along this axis to the condensing lens.

An Automatic Arc Control.

A single motored projection arc control has made its appearance on the market. This control is marked by its absolute simplicity. It consists of a magnet connected across the arc terminals through a suitable resistance. The armature of the magnet coils is normally held away by an adjustable spring, the latter being adjusted after the proper arc setting has been determined upon. When the voltage across the coil increases the armature is attracted toward the magnet coil, and in so doing, completes the feed motor circuit. The motor, working through a gear ratio of about 800 to 1, feeds the carbons together until they reach a position where the voltage is insufficient to hold the armature against the spring tension. The latter, therefore, causes the armature to break the motor circuit.

Camera Motor.

A manufacturer of motion picture cameras has successfully designed a small compact motor for operating cinema cameras. To be successful, such a motor must be exceedingly accurate in balance so that there will be no vibration present. With this motor in use and operated from a storage battery, the cinematographer is able to give his entire time to the task of keeping his scene in its proper place in the frame.

Color Studies.

Although not technical in its methods of application, it is interesting to note that some of the larger producers of film have been brought to recognize the value of properly preparing the tones of scenes and sets in order that the correct color values and relations may be evidenced on the final black and white screen picture. Color experts are now brought into consultation when lavish sets are being prepared.

Fireproof Structures for Exchanges.

Through the efforts of the various Fire Protective Associations and the film manufacturer, special structures to house film exchanges have been erected or are being erected in the distributing centers of the industry. Many of the older Exchanges represented fire hazards of the worst type. The new buildings are fire-proof in every particular, and have been built to incorporate the ideas of those most experienced in the handling and storage of film.

A. R. DENNINGTON, *Chairman.*

PAPERS COMMITTEE REPORT

MR. KETTERING expressed the chief aim of your Papers Committee, when he said last night that engineering will advance most rapidly by the exchange of information. There are, in general, two ways in which data is exchanged—one, through personal contact and good fellowship; the other, through the presentation and discussion of papers.

It is the privilege of your Papers Committee to have most to do with the latter. In carrying on our work, we have tried not only to secure papers that would interest you and record progress in the various branches of the motion picture industry, but also to accomplish a little broader work by devising ways and means for the committee to become more permanently useful to the Society.

Your committee had thirty-six (36) prospective papers lined up in preparation for this convention. Out of these we finally secured the papers which you have heard. We would call to your attention the fact that the arrangement of an interesting and valuable program is seriously handicapped by those who promise papers and then fail to finish them in time for the convention, or fail to deliver them after they have been finished.

We realize that occasionally conditions arise which necessitate the withdrawal of a paper, or a change of its scheduled time for presentation, but we urge upon authors that every effort be made to prevent such occurrences.

We have made earnest efforts to find out from the membership of the Society the subjects in which they are most interested. We have even written a letter to every member of the Society asking for suggestions on convention papers. This has met with very little response. In lieu of such information, we have analyzed the papers that have been presented and tried to secure subjects on which information is more or less lacking and which are of importance in the industry.

However, the convention is primarily yours, and if you will tell us what you want in the way of papers, we shall make every effort to try and secure them for you.

We would suggest, that before this convention is over, while things are fresh in your mind and you are enthusiastic, you get in touch with some member of the Papers Committee and make suggestions for the Spring convention, as your committee starts work on the Spring convention the day that the present convention closes.

After a convention is over, your Papers Committee has experienced considerable difficulty in securing for use in the Transactions complete texts, photographs and drawings for the papers which have been given. Unless the Transactions are issued promptly after a convention, they lose materially in value.

There is a great deal of work entailed in the preparation of the Transactions; not only do the texts, drawings, etc., have to be

secured edited and turned over to the printer, but the proof has to be read, sent to the author for correction, and perhaps reprinted and returned for further correction. All of this takes time and the burden of the work falls largely on the Committee on Publications.

It is absolutely impossible to publish the Transactions promptly unless the authors cooperate and send in their material shortly after the convention.

Next year, by action of the Society, you have authorized the carrying out of the recommendations which your Papers Committee has made; namely, that papers be printed and distributed in advance of the convention and that at the convention, extracts or synopses only, of the papers be read; the majority of the time being devoted to discussion.

You have also authorized having a public stenographer present to take down the discussions, and that the discussions appear together with the full text of the paper in the Transactions. Your Committee believes that as the paper itself is only one man's opinion on the subject, it will be made much more valuable when thoroughly discussed by numerous people. In order to accomplish this, however, it is *absolutely necessary* that the *texts* of papers for the convention *be in the hands of the Papers Committee four weeks in advance* of the convention. We would call this to the special attention of prospective authors for the Spring convention, asking their cooperation in this matter.

You have also, by recent action, agreed to your Papers Committee recommendation that extracts of the discussions given at the present convention accompany the papers when they appear in the Transactions. You will realize that it is impossible for our secretary to record long-hand the various discussions and we, therefore, point out to those who discussed papers the necessity of promptly sending either to the secretary or to the Papers Committee their discussions.

We would also recommend that extracts of actions taken by the Board of Governors, and by the convention as a whole, appear in the Transactions.

By way of more permanent work, your committee recommended some time ago that a new committee be formed, to be known as a "Committee on Progress"; this committee to report at each convention things of interest which have been accomplished in the various branches of the industry since the last convention. We are proud of the two reports which we have had from this committee and think they have demonstrated the value and permanence of this work.

We believe that it would be of great assistance to extract any articles appearing in the Transactions of other technical societies, or in the press, which pertain to the work of the Society of Motion Picture Engineers, and we believe that a permanent committee should be formed to give such a report at each convention, this being a part of the committee's work, the chief aim being cooperation with other organizations. We would, therefore, recommend the formation of a Committee on Reciprocal Relations.

We believe that the Utilities Committee, which was appointed at the request of the Papers Committee, proved its usefulness and service at this convention, and we trust the committee will be retained as a permanent part of our Society.

Your committee has enjoyed its work during the past year and wishes to thank the Society as a whole for their support, and in particular the members with whom we have worked more directly. During the course of this work we have perhaps learned some things and secured some data which might be of assistance to the Papers Committee for the coming year, and we should be very glad to place such information in the hands of this committee whoever they may be, and cooperate with them to the best of our ability.

L. C. PORTER, *Chairman.*

Report on Committee to Consider Correspondence Course for Projectionists

IN order to get some idea of what should be included in a correspondence course for projectionists, a general outline covering the principal subjects has been prepared. This outline is not expected to be complete in its present form, but may be considered only as a skeleton to be developed as the work progressed. The outline follows the general plan adopted by the International Correspondence Schools, and an effort has been made to present the various subjects in a logical order, though it is realized that there are a number of discrepancies in the first outline which has been made up. There are also a number of omissions in listing apparatus, as it has not been practicable to spend the time which would have been required to make a complete and detail outline of the complete course.

Plan for Obtaining Material:

Little difficulty would be found in obtaining from various manufacturers of equipment special information regarding the apparatus or devices which they manufacture. This is the plan which has been followed successfully by the International Correspondence Schools. In some cases an employee in a manufacturing establishment has been hired by the Correspondence Schools to write a booklet or a series of booklets giving details of the apparatus manufactured. I doubt if it would be necessary to hire any employee in the various industries connected with the motion picture business, as the advertising value which these manufacturers would obtain would amply repay them for any effort in furnishing information.

Preparation of Material:

After obtaining descriptions of apparatus and the important facts involved in any special section, it is absolutely essential that this material be carefully edited. The entire success or failure of a course depends largely upon the editorial work. It must be kept continually in mind that the material is to be presented in such a way that it will not only be interesting but will be easily understood by the reader who has not had the advantage of any technical training, and perhaps nothing more than a common school education. The text should be illustrated with very complete diagrams and half-tone cuts. Many of the points would require the making up of wash drawings in order to bring out the details which would need to be emphasized. Therefore, in addition to the editor, it is important that the illustrations be made up by someone who has had experience with or is conversant with the making of illustrations for correspondence courses.

Printing and Distribution:

After the material has been prepared for printing, it is essential that a high quality of paper and good clear type be used, as, otherwise, the effort to present the subject matter in a clear, concise manner may be almost offset by a poorly printed page. Economy in the matter of paper in press work would be ill-founded in the making up of a successful correspondence course.

In the outline which has been made there are ten general subjects covered. It is estimated that these ten subjects would require booklets of 25 to 100 pages each, and the average would probably be 50 or 60 pages.

Estimated Costs:

Assuming that provision be made for distribution of 5,000 copies of the correspondence course, and that the total number of pamphlets in the course is ten, and that these pamphlets would be issued at different periods, the printing cost would probably be about $1,000 per pamphlet or a total of $10,000. The editorial work required would mean at least one year, and the estimated cost of this work is $3,000. Time of drafting required for illustrations would amount to approximately $2,000. Incidental expenses—traveling, etc., $1,000. The estimated cost of preparing the course would, therefore, be $16,000.

There are additional items of advertising, and the cost of distributing the books to subscribers, which are not included, but it is very doubtful if any study course could be prepared for less than the amount given.

A. R. DENNINGTON, *Chairman.*

Extracts of Action taken at Board of Governors Meeting, Hotel Miami, Dayton, Ohio, October 10, 1920

THE following applications for active membership were presented and accepted.

Mr. F. Morrison, of Barr & Stroud, Ltd., England.
Mr. P. R. Bassett, Sperry Gyroscope Co., Brooklyn.
Mr. C. A. Ziebarth, Bell & Howell Co., Chicago.
Mr. A. S. Howell, Bell & Howell Co., Chicago.
Mr. J. H. McNabb, Bell & Howell Co., Chicago.
Mr. Proksa, Universal Tool & Die Co., Chicago.
Mr. H. F. Barnes, Edison Lamp Works, Harrison, N. J.

The following applications for associate membership were presented and accepted:

J. Hornstein, Howell Sign Equipment Co., New York City.
H. A. R. Dutton, Exhibitors Supply Co., New York City.
I. L. Nixon, Bausch & Lomb Optical Co., Rochester.
H. L. Gage, Toronto, Canada.

The following resignations were presented and accepted by the board:

D. J. Bell, C. B. DePue.

The Treasurer stated that the Society's finances were in a healthy state, having $2459.24 cash in the bank, about $100 due on 7½ membership dues still unpaid, about $470 due on advertising and considerable coming in as dues from new members. Against this, all outstanding bills amount to about $900.

The Treasurer was instructed to present a detailed statement showing the Society's net assets at the closing of this year's books.

The Treasurer stated that he had had himself bonded as treasurer of the Society.

It was pointed out that through a typographical error the name of Mr. B. R. Proctor was omitted from the latest membership list. This will be rectified at once. The secretary is to make a complete list of all members in good standing a part of the minutes of each meeting.

The question of the sale of Transactions was discussed. The Secretary suggested the preparation of a pamphlet giving titles and synopses of all papers presented before the Society to be distributed to projectionists and others.

Mr. Burrows suggested supplying salesmen of motion picture equipment with copies of the Transactions to be purchased by the salesmen or the concerns they represent.

Mr. Campe suggested running half page advertisements in the trade journals.

It was finally decided to prepare the booklet suggested by the Secretary and to run a small advertisement bearing the Society's emblem in the trade papers stating that such a pamphlet and price list would be sent upon request and receipt of postage. It is anticipated that this will result in the sale of many Transactions.

It was decided to charge $.25 for any of the Transactions previous to those of the Pittsburgh meeting; $1 for the Pittsburgh Transactions and all later ones until further action is taken.

Mr. Roebuck exhibited the new application blanks and stated that two had been sent to each member of the Society.

It was decided that at the next convention the papers will be printed and distributed in advance and that at the meeting, synopses only will be read, devoting the majority of the time to discussion. Each speaker is to be limited to a definite time. A court stenographer is to be provided to record the discussions. These will be edited by the Papers Committee and appear with the complete text of the paper in the Transactions.

The secretary was instructed to send one set of the Transactions of each meeting to any and all other societies throughout the world whose work is similar to or bears on that of our own and to secure their transactions in exchange; these transactions to be extracted by a committee and presented as part of the Papers Programme at each meeting hereafter.

It was decided to use the Society's official seal on all future membership cards.

L. C. PORTER, *Secretary pro tem.*

History of the Motion Picture

By C. Francis Jenkins

I HAVE been asked by your Papers Committee to prepare a sketch of the conception, early history and development of the motion picture, but to compile an accurate account sufficiently complete without being too lengthy is not an easy task.

Where the motion picture idea originated I have not found out, though a hundred years before the Christian era, Lucretus strangely wrote his friend thus:[2]

"Do not thou moreover wonder that the images appear to move and appear in one order and time their arms and legs to use; for one image disappears and instead appears another arranged in another way, and thus seems each gesture to change; for you must understand that this takes place in the quickest time."

This is an exact description of the motion picture of today, and if this is really what he meant, then it took two thousand years to get a suitable picture ribbon and a proper machine to handle it. And it will be noticed that the subject naturally divides itself into these two main elements, i. e., the picture-carrying vehicle and the handling mechanism therefor. The mechanism is of two kinds, i. e., one of them continuous movement, the other intermittent movement of the picture carrier at the illuminated aperture. The process, as we know it today, is likewise divided into two steps; the first a photographic analysis of the animated subject, the second a synthesis of the elements into which the subject was divided by the analytical process.

The success of the attempt to simulate animation depends initially upon persistence of vision, that faculty of the human eye which enables the retina to hold onto a light sensation for an appreciable time after the light is cut off. And curiously enough this phenomena seems to have been first mentioned by a blind man.

The motion picture is not a sort of Minerva-birth of inventive genius, but like all notable achievements in mechanisms has had a long line of predecessors, for the difficult problem of recording and reproducing motion did not yield without much preliminary fumbling.

Obviously it would lengthen this paper beyond acceptable limits if description were made of the work of all who have contributed to the result in the form finally adopted and practiced at this time. I shall therefore endeavor to confine myself as far as this may be done to mention of the contributions of those who in turn first added a new step in the development of the idea.

By a process of knowledge additions and eliminations the motion picture of today reduces itself roughly to six historical periods; the first (1) a series of related picture elements; (2) the adoption of

[2] De Rerum Nature, book IV, verse 766.

photography to secure them; (3) the use of a single camera; (4) of perforated film; (5) of intermittent film movement; and (6) in making the period of illumination exceed the period of change or substitution of a new picture element, or frame, for the last in sequence throughout the series.

The first motion picture mechanism we have any record of is the zoetrope, or wheel of life, though its origin is buried in antiquity. It may be that this is the device Lucretus was writing about. It usually consists, as you all doubtless well know, of a paper cylinder having equi-spaced axial slits cut through its wall. Between the slits on the inside were arranged sketches of successive phases of an object in motion. By whirling the cylinder and viewing the sketches through the slits as they passed the eye one got the sensation of an object in motion.

The Zoetrope

The picture series were also put upon a slotted disc (this form may have antidated the drum type) and were viewed by looking through the slots at the reflection of the pictures in a mirror as the disc was whirled.

The first attempt at projection followed this line, that is, transparencies were mounted in disc form and illuminated from the back, a projection lens imaging these on a screen as the successive pictures of the series were momentarily exposed in the field of the lens.

Plateau, who seems first to have made up such a mechanism, mounted sixteen pictures on his disc, suitably illuminated them through a whirling opaque shutter having a single radial slot therein, the shutter disc rotating sixteen times as fast as the picture disc. Though blind, Plateau appears to have given diligent study to this persistence of vision phenomena, and at this early date, 1849, curiously enough, hit upon the same picture frequency now universally used. This picture disc, intermittently illuminated, was subsequently employed by several experimenters.

Another form was exactly the reverse of this plan, for instead of a single stationary lens and stationary light with a 16-picture transparent disc revolving between, consisted of a stationary disc with 16 pictures and 16 lenses, a single lens mounted in front of each picture, while the light whirled around to momentarily pass through each picture and adjacent lens. As all the lenses were adjusted to register at a single spot on the screen, the composite on the screen appeared, by persistence of vision, as a single uninterrupted picture.

The idea of simulating motion by intermittent illumination of a series of related picture elements seems to have been the preferred method for more than a hundred years, the last of the line being Edison's Kinetoscope of 1894 (to be described later).

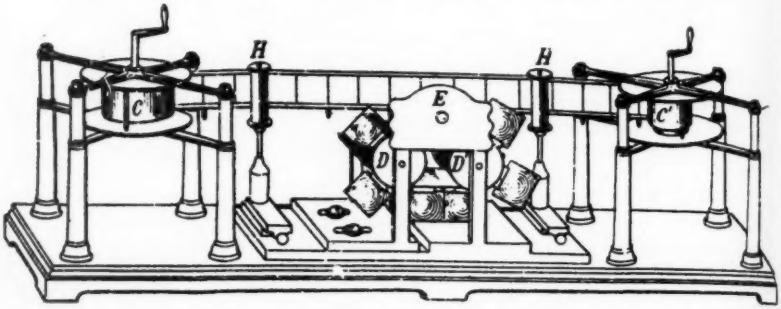
The picture series were first made in a camera in 1860, to the best of my knowledge, by Colman Sellers, an engineer, who, in one form, pasted the photo prints on an endless band for exhibition.[3]

[3] Sellers, U. S. Patent No. 31,357, issued Feb. 5, 1861.

In 1894, I met Mr. Sellers who described his devices to me and gave me photographs of them and also strips of pictures used therein.

An acquaintance of Colman Sellers, and likewise a Philadelphian, Henry R. Heyl, also made camera plates (of a dancing couple in action) making from the negatives wet-plate lantern slides which he mounted disc-wise, and revolved, step-by-step, in the light of a projection lantern. He gave a public demonstration at the Academy of Music, Philadelphia, Feb. 5, 1870.[4] I have paper prints off the negatives, which he gave me in 1895.

An examiner in the U. S. Patent Office, some ten years after allowing me a patent on a perforated picture strip in continuous and synchronous motion with a plurality of lenses passing a fixed open-



Projector with plurality of lenses.

ing in a camera, called my attention to an anticipating French publication, of March 1, 1864, in which Sr. Ducos illustrated and described much the same thing, i. e., a flexible picture band carried along by a sprocketed drum, synchronously with a plurality of lenses.[5]

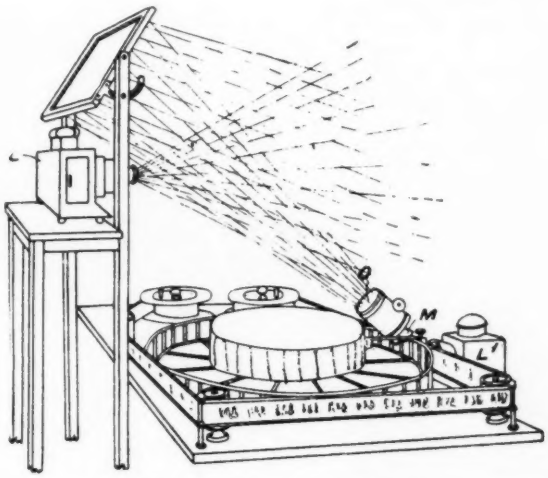
The first use of the now almost universally employed geneva gear or star-and-cam in projectors appears to have been made by A. B. Brown, in 1869.[6] However, the use of this type of intermittent gear is practically the only interest his contribution has for the historian.

Marey, a French scientist, employed the zoetrope, the slotted cylinder described earlier herein, with solid figures instead of pictures, modeled in imitation of successive phases of an animal in action, which not only gave the action but the placticity of solid bodies. One of his instruments of this type is still to be seen in the Museum of the Paris Physiological Station.

A variation of the picture-carrying drum, employed as a projector, had a series of vertical mirror-strips for reflecting the light beam which carried the picture to the screen. It depended for success

[4] Franklin Institute Transaction of this year (1870).
[5] Unpublished French Patent, July 5, 1864.
[6] U. S. Patent 93,594, 1869.

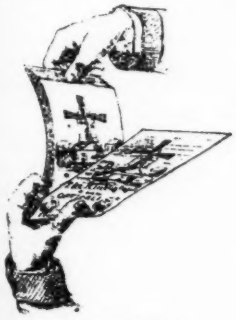
upon the reflection phenomena that, to accomplish the desired result, the angular movement of the mirror must be but one-half that of the picture movement. Reynaud, in 1889, made such a device



Reynaud's improved version of the Zoetrope.

which was to be seen on the boulevards of Paris until the present type projector deprived it of public favor.[7]

Aside from the ribbon form of picture carrier, another which attained considerable popularity in its final and perfected form consisted in mounting the picture series as the leaves of a pad or book, which, bent back and exhibited by slipping from under one's thumb, brings the picture into sight in such rapid succession that a very good motion picture is produced.

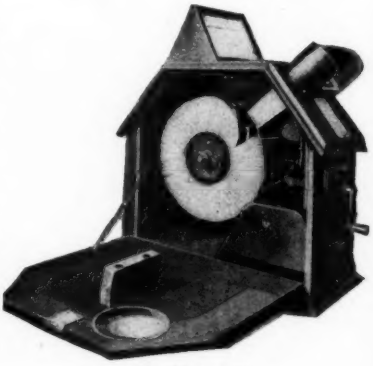


The Thumb-book

The first mention I have been able to find of these thumb books, as they came to be called, was the invention of Linnett in 1868.[8] They appeared from time to time in one form or another, sometimes being mounted in a holder with a mechanical detent to press back the cards.

[7] British Patent 2,295 of 1889.
[8] British Patent No. 925 of 1868.

The most pretentious of these instruments was the Mutoscope of Herman Castler[9] in 1895. The picture cards stood out radically from a drum to which they were attached by their bottom ends, a thousand or more on a single drum, and these slipping from under a detent exhibited the pictures thereon with smoothness and precision. It was a coin operated machine and "picture parlors" equipped with Mutoscopes were established in the large cities, seaside and mountain resorts and pleasure parks, holding the public favor until the advent of the 5c-movie theatre.



The Mutoscope

The Phantascope

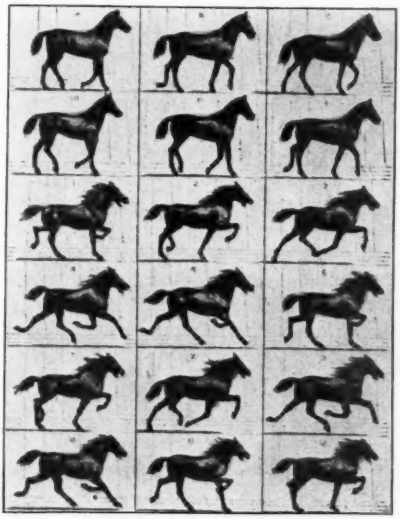
The Messrs. Lumiere, of France, brought out a similar machine which they named the Kinora. The striking feature of this machine was the curved picture-carrying cards, curved to add resiliency.

My own contribution to this line was a Phantascope toy,[10] in which a flexible band was employed, the cards being attached thereto by their lower ends and having a spaced relation of about five thousandths inch. This close spacing of the cards assured a firm adhesion to the band and to each other when a flexible glue was used.

But it is to the persistence of Edward Muybridge that we are indebted for the most scientific research in motion analysis, work which he began in 1879. His animal studies became classics with artists. Wet plates only were then available and he used above half a million of them in a plurality of cameras arranged in order along a track over which his subject was required to pass. He thus obtained consecutive impressions at regular intervals of time and distance during a complete stride.[11] His first work was financed by the

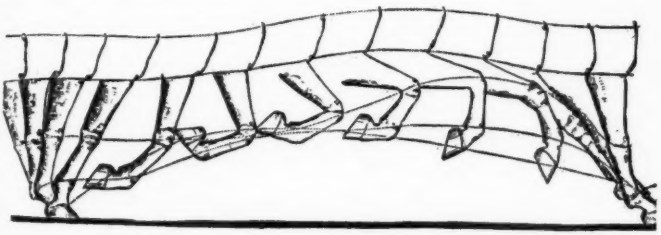
[9] U. S. Patent No. 549,309, 1895.
[10] U. S. Patent No. 779,364, 1905.
[11] Franklin Institute Journal, April 1883.

Hon. Leland Stanford, of California, a lover of fine horses.[12] Between 1883 and 1887, he was engaged in like work at the University of Pennsylvania, where his "Animal Locomotion" was published.



Some results of Muybridge's experiments.

On February 27, 1888, Mr. Muybridge interviewed T. A. Edison as to the possibility of combining his Zoaproxiscope projector with Edison's phonograph, but without result, though Mr. Edison did exploit such a combination some years later.



Dr. Marey's experiment with phases of animal locomotion.

The next to come prominently into notice was Dr. Marey. Sometime after meeting Muybridge in Paris, in 1881, where Prof. Muybridge was exhibiting at the Electrical Exposition, Marey set

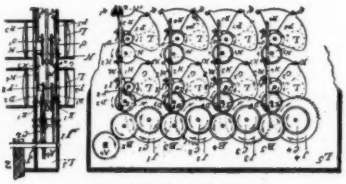
[12] The Century, July 1, 1887.

about to determine by graphic methods the trajectories, velocities and accelerations of moving parts of the human body, acquiatic locomotion, etc. At first, he used plates but later, 1888, used "a long roll of sensitive film" intermittently fed past the exposure aperture.[13] His work has a permanent value to science.

In 1887, Auchutz published[14] a description of his tachyscope, a device which was later shown at the World's Fair, Chicago, 1893. The apparatus consisted of a glass wheel the pictures on which were lighted by the flash of a vacuum tube as they came into position; though the machine is the same as that described by Donisthrope, of London, in *Nature*, issue of January 24, 1878.

To concentrate a considerable length of entertainment on a convenient area a disc picture carrier was attempted by several inventors. In one scheme a glass plate was employed upon which series of pictures were spirally arranged, as in the Anthony device.

A British patent of 1900 to Rosenberg discloses another plan, a film having two rows of pictures thereon, each row being half of the whole show. At the end of the first row the film was shifted and run in the opposite direction to show pictures of the second row. Edison in his home projector of 1911 followed the same scheme.



The LePrince Patent

In 1886 Augustus Le Prince, of New York State, filed an application[15] for U. S. Patent which disclosed transparent picture ribbons having a row of perforations along each edge of each film. Four such strips were used in the machine, four pictures being made on each in succession behind sixteen lenses. A single lens modification is suggested, with perforated film driven by a sprocketed drum.

It is curious that those who came nearest anticipating future accepted methods and mechanisms should have failed to follow up their work. As another shining example I might cite Mr. Levison, who publicly exhibited at the Brooklyn Photo Club an apparatus

[13] Academy des Sciences, Comtes Rendus 1888, CVII, page 677-678.

[14] Philadelphia Photographer 1887, p. 328-688.

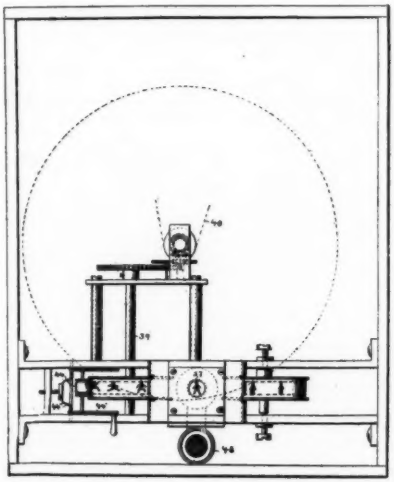
[15] Serial No. 217,809; Patent No. 376,247.

much like present day devices; it had flexible film, moved step by step, and behind a single lens.[16]

Plates, cards, paper strips, drums and glass discs had been used for animated pictures, but when in 1885 Rev. Goodwin invented the transparent celluloid flexible film the way was opened to rapid advance, for the necessary unlimited capacity in the picture carrier was then possible.

In 1889, Mr. Dickson began, at Thos. A. Edison's direction, the development of a picture machine.[17] News of what was being done appeared in print from time to time and the summer of 1894 saw the beginning of the public exhibition of his Kinetoscope, a box into which one looked to see picture in animation.

The picture ribbon was passed continuously between a small lamp and the eye of the observer, the view being cut off by a rotating disc about a foot in diameter and having a one-eighth by one inch radial slit therein near the periphery. Through this flying slit the observer got a momentary sight of each picture frame as it



Appearance of first Kinetoscope.

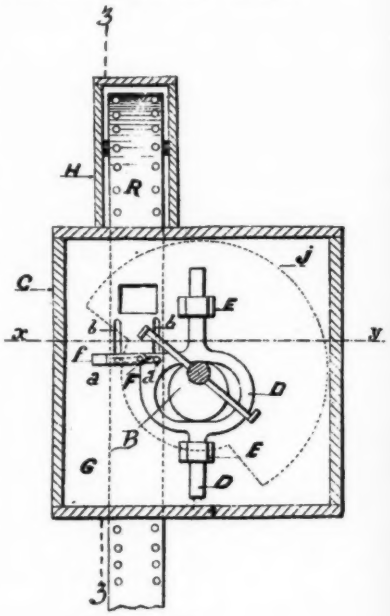
came into position above the light. The frames passed at the rate of 46 per second, a high speed being required because of the instantaneous view and meagre illumination. The pictures were small,

[16] Brooklyn Eagle, and Brooklyn Citizen, both of June 14, 1888.

[17] Scientific American, June 20, 1891, also U. S. Patent 493,426.

of course, but excellently done. The excellence of the Edison pictures without doubt proved a stimulus to the rapid development of the art, far more than any contribution in mechanical design or new methods, as was later demonstrated when the courts held that the Edison patents and re-issues were anticipated and invalid.

Among the early English workers were Friese-Greene and Mr. Evans who exhibited a camera before the Bath Photo Society, February 25, 1890, and in 1895 were working on a projector, work which was concurrent with the work of the Lumiere Brothers in France. The Lumiere camera was also used as a projector, however, and as such came to America in 1897.

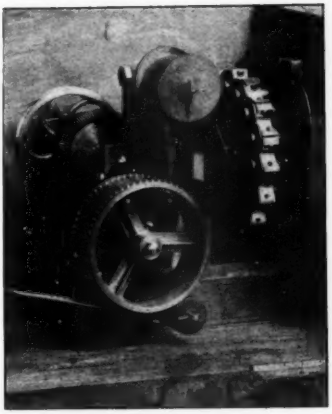


Lumiere Camera

The American Biograph, built by Herman Castler in 1896 was one of the very best of the projectors of these early development years. He worked on the theory that the larger the frame the sharper the definition on the screen because of the less enlargement required. This machine used 2¾" width of film. The film, unperforated, was advanced through the projector by the griping action of mutilated cylinders which contacted for only a fourth of a revolution. The resultant screen picture was excellent, but like all the other mechanisms employing film differing from the generally accepted standard, had its day, played its part and dropped from sight.

In 1890, I began work on mechanisms for recording and reproducing motion. Two systems were developed side by side; one employed intermittent motion at the picture aperture, the other continuous motion. Cameras were first made, in which film was used, split to width in the dark from Kodak film bought in local photographic shops. These pieces were spliced into strips, sometimes twenty-one feet long, if I was lucky. Prints were made from negatives exposed in the cameras—usually in the continuous motion camera, for it made the steadiest pictures, though projection was mostly in the intermittent machine which had no interrupting shutter and therefore gave most illumination.

The continuous motion mechanism consisted of a rotating disc carrying a plurality of matched lenses arranged around its periphery and passing in single line sequence across an adjustable opening in exact synchronism with a film moving downward in the focus of the lenses. Different mechanisms were made, with an equipment of lenses ranging from five to forty-eight and in spaced relation depending on the height of the frame chosen.



Continuous motion mechanism with plurality of lenses.

In the intermittent mechanism the film was illuminated for about seven-eighths, and moved in about one-eighth of a period. A "beater type" was first employed and later followed by the geneva gear, a gear found in many makes of watches to prevent winding the spring too tight.

My work was my own, but viewing the art in historical retrospection from this late day, it is evident that the solution of the illumination problem was my only original contribution to the art as practiced from 1890 to the present time. I must confess that I don't quite understand why the thing wasn't hit upon by someone previously, it was so simple and so perfectly obvious when once done; like the half turn of the screw which made the constant contact transmitter, which, in its turn, made the telephone a commercial article.

All my old apparatus was acquired by the United States National Museum in 1895 and there it can still be seen (on exhibit in the Graphic Arts department).

My projectors were motor driven and by some accident of design were built left-handed, a type which has since been followed, consciously on unconsciously, in the design of machines the world over.

Exhibitions to friends were given from time to time in 1891, 1892 and 1893, though my first exhibition of which any account appeared in printed publications, was in June of 1894.[18]

In March following I secured the financial assistance of a local man and we built three copies of this early machine and exhibited them at the Cotton States Exposition, Atlanta, 1895.[19] These were the first of picture shows in a building built exclusively for the purpose.

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[18] Richmond Telegram, Richmond, Indiana, June 6, 1894.

[19] Baltimore Sun, Oct. 3, 1895; Atlanta Journal, Oct. 21, 1895; Albany, New York, Times-Union, Oct. 21, 1895.

In the winter following, I demonstrated the original instrument, the Phantoscope, before the Franklin Institute of Philadelphia[20] and at the close of the demonstration it was voted that the matter should go before the proper committee to determine whether it ought to receive scientific acknowledgment. The Committee in due course recommended the Elliott Cresson Gold Medal and published its findings in the Journal for three months. Thereupon the proposed award was vigorously opposed by two interested gentlemen, but after many months of taking testimony and considering evidence and data submitted, the originally recommended award was made. Eighteen years

The original Jenkins lateral projector.

later a second award was made, the John Scott medal, for improvements, i. e., lateral projection, as demonstrated in a machine which I later christened the Graphoscope.

Efforts have been made from time to time to exploit synchronized pictures and sound, but without success. There is no difficulty in synchronizing. This has been accomplished in several ways by those engaged thereon, my own scheme being to put the sound record on the film as a sinuous edge so that accidental destruction of a part of the film would take out as much sound as picture, and when spliced again would still be in synchronism and without any adjustment of mechanism. The public, however, did not favorably receive any of the singing pictures and all such schemes disappeared when the novelty of a single exhibition had passed. The silent drama

[20] Franklin Institute Bulletin December 1895 and Franklin Institute Journal, January, 1896.

is attractive to a very large extent, I think, because it *is* the silent drama.

Stereoscopic motion pictures have been the subject of considerable thought and have been attained in several ways, as described in the October, 1919, transactions of this Society, but never yet have they been accomplished in a practical way. By practical, I mean, for example, without some device to wear over the eyes of the observer. It is generally conceded that its acceptable accomplishment would enhance the beauty of the motion picture.

Motion pictures in natural color have been attained by several persons, one of the first to have wide public exploitation was that employed by Smith and Urban (Chas. Urban, one of our members). The film had color stencil frames alternating longitudinally of the film and which were projected respectively through red-yellow and green-blue tinters so that the film running through the machine at twice standard speed produced a composite screen picture in natural color and motion.

Gaumont in 1913 had a color scheme in which three rows of frames were arranged side by side on a wide film, each row being projected through its appropriate tint and, superimposed, produced a screen picture in natural color. With a synchronizing attachment sound was also added giving "talking motion pictures in natural color."

As each of these schemes required special apparatus difficulty was experienced in exploiting these processes and they fell by the wayside.

The process which will succeed is that which fits standard machines without change. Such, for example, as that patented[21] by Arturo Hernandez and skillfully developed by one of our members, Mr. Kelley. This was demonstrated at our Philadelphia meeting and described in the transactions of November, 1918, and April, 1919. It consists, as you will remember, of a double coated film, the red-yellow frames being on one side and the blue-green frames on the other side of the film, each side tinted in its proper color throughout the length of the film. Such a natural color film can be run in the standard projector without change, and can, and often is, put into a split reel with monochrome film.

The suppression of flicker (and resultant headache) was the next problem to attract attention and the first mention I find is in 1900[22] and the description says that "the shutter rotates once in the interval between the movements of the film."[23] But as more commonly practiced flicker is subdued by adding one or more blades rather than by rotating the shutter oftener.

In France the Pathe Brothers have a notable establishment in which the requisites for the entire motion picture process are

[21] U. S. Patent 1,174,144.

[22] British Patent No. 2283 of February 5, 1900.

[23] From Digest in U. S. Patent Office Library.

produced, i.e., raw stock, cameras, laboratory equipment, studio and projectors. In England Chas. Urban for several years maintained a similar plant and his accumulation of educational and scientific subjects are probably unequalled anywhere.

We have no similar establishment in America, the Yankee being more prone to specialize. And my sketch would be incomplete should I fail to mention the impetus initially given to quality picture production by Messrs. Bell and Howell, makers of fine cameras and printers. Another who has made himself paramount in his specialty, picture printing, is Mr. Rothacker. Both Bell and Rothacker are members of our Society. And just here let me note that quality production has been possible by the uniformly high standard of raw stock furnished by George Eastman, represented in our Society by Mr. Blair.

Projection has not been developed to the same high degree, perhaps because the accomplishment is far more difficult. The analytical end of the motion picture process has always been the least troublesome, principally because of the ample time latitude of film movement in the camera and printer. The projector still lacks the 100% quality for 100% of time of a completely developed machine, in addition to an efficiency of but 50% in light utilization.

And yet I think it one of the most remarkable mechanisms extant. Consider its intermittent sprocket for example; it handles a thousand feet of fragile and delicate film per minute, with a start-and-stop motion, at a speed of 150 feet per second at the maximum point, stopping it with so nearly microscopical exactness that, magnified, say, four hundred diameters, and repeated sixteen times a second, the unsteadiness is almost nil.

As for players our art now has such popularity that few actors and actresses of the speaking stage have been able to resist the lure of the silent drama, despite their prejudice, though none of them has made so great successes as those of less or no foot-light experience. Apparently stagecraft and cameracraft don't "gee." Certain it is that new names have attained stellar brilliance in the pictures, the new medium of expression having developed a new type of artist both in acting and in direction.

But we should not forget that while our art as an industry is the fifth largest in the world, and money has been spent with reckless disregard of values, it was the courageous spirit who established the first 5c movie house who made such expenditures and such returns possible. This was the real beginning of the expansion which made an industry of a scientific plaything, and a film exchange system which has endured to this day. For just as the central exchange made the telephone widely useful, so the movie theatre made the motion picture a profit paying entertainer.

So, as Sargent happily puts it, for fifteen years now we have had a device for dramatic representation which has given us every form of entertainment known to man since the beginning of time. We present the story teller in a pantomine far more effective than mere words alone; we show every form of spectacular reproduction

in a splendor never dreamed of by a Caesar; we present every human emotion known to exist in a realism and costume true to nature; we multiply the magic lantern a thousand-fold in every reel; we bring every distant country, every strange people, every quaint custom, every new and wonderful invention, every scientific discovery; all this we bring to the stay-at-homes and an humble coin pays the fiddler. The child of today has seen more of the world than did the traveler of yesterday.

Many great enterprises have begun with the doing of some very simple thing. So in motion pictures when the opening in the shutter was enlarged scientific grouping stopped and the development of an industry began, an industry grown already to great magnitude. But I firmly believe that because of its universal usefulness, the ability to convey information between all peoples of the earth (for you should remember that it is without language or literacy limitation), the motion picture is destined ultimately to be the greatest single industry known to mankind. I think, therefore, fellow engineers, we may justly be proud of our vocation.

REPORT OF THE OPTICS COMMITTEE

SINCE the last meeting of the Society the Optics Committee has repeated its former tests on the effect of color in projection, using a method not subject to some of the possible errors of the former one. When the film itself was dyed there was a chance of the dyeing material affecting the clear and opaque portions of the film to a different degree. Accordingly in the recent tests two uncolored loops from the same film were used, the picture being of a stationary object to insure equality. Each was then run through a machine—the machines being as nearly alike as possible—and the two pictures thus obtained were thrown side by side on the screen as before. A large piece of dyed gelatin was held just beyond one objective. The observers sat near the center of the room, so as to see both screens from the same angle, and recorded which picture seemed brighter, which clearer, and which of greater contrast—the colored or the black and white.

A metal mesh that intercepted half the light was next put over the objective used with the uncolored picture, and a second record was then made by the observers. A third and fourth record were made with the uncolored light reduced by meshes to ¼ and ⅛ of its initial value respectively. Before each comparison the screen was darkened and the room lights turned on to bring the eyes of the observers to approximately the same sensitivity each time.

Above is given a table of the results. Columns 1 and 2 give the number and name of the color, column 3 the percentage of the light falling upon the filter from a tungsten filament at 2880°K, that is transmitted. This percentage had been previously measured with a flicker photometer.

There are nine columns under each heading, Brightness, Clearness, and Contrast. The figures under columns *b* denote the number of observers that thought the brightness, clearness, or contrast of the colored picture to be equal to the uncolored one without intercepting mesh. Under columns, *d*, *f*, and *h*, is given the number who considered the colored picture equal to the uncolored picture when the latter was reduced by a mesh to ½, ¼, or ⅛ full brilliancy. Similarly columns *c*, *e* and *g* give the number of observers who recorded the point of equality as lying between the adjoining columns, and *a* and *i* beyond. For example, in color 1*a* three observers thought the contrast in the colored picture to have been less than in the black and white at full brightness, but greater than in the black and white reduced to one-half brightness.

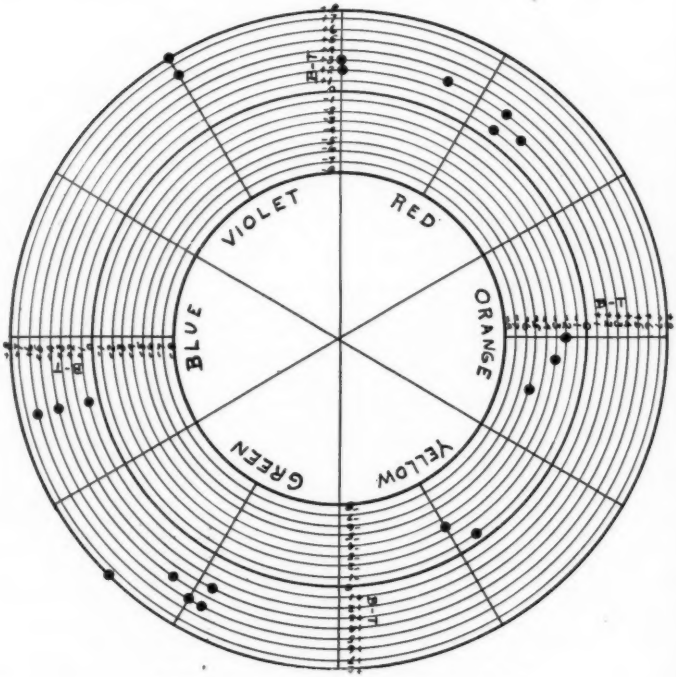
The colors were run through twice. The results of the first trial are given in the top half of each square and of the second in the lower half. In every case the readings indicate a gain by the colored picture in relative clearness and contrast, as well as brightness, each time the brightness of the uncolored light is reduced. This of course means that when any observer has decided that the

TABLE

No.	Transmission	Color	BRIGHTNESS	CLEARNESS	CONTRAST	AVERAGE	Transmission	B-T
			a b c d e f g h i 1 1/2 1/4 1/8	a b c d e f g h i 1 1/2 1/4 1/8	a b c d e f g h i 1 1/2 1/4 1/8	B. Cl. Co.		
1a	35	Purple	4 1 4 1 3 3	1 1 6 1 1 3 2	3 1 4 1 2 2 2	d- e e	e	2
1b	24	Purple	1 1 5 1 2	2 3 1 1 1 1	2 4 1 2 2 1	e e e-	f	3
2a	28	Scarlet	1 5 2 1 3 1	1 4 2 2 2 1	5 2 1 2 2	e e e-	f	2
2b	45	Scarlet	5 3 1 2 3	4 4 1 1 1	4 3 1 1 4 1	d d- e	d-	1
3a	70	Orange	3 4 1 2 3 1	1 4 3 2 3 1	3 3 2 2 3 1	d d- d	e	-2
3b	62	Orange	2 4 2 2 1 1	1 3 1 1 3 1 1 1	1 3 2 1 2 2 1 1	d- d- d	e-	-3
4a	88	Yellow	1 4 2 4 1 1	1 3 3 3 2 1	1 2 4 2 2 2	e- d d	b-	-3
4b	87	Yellow	4 3 1 4 2	5 2 2 3	6 2 1 2	e e e	b-	-1
5a	28	Green	1 2 2 2 1 4	1 3 2 1 1 1 4	1 1 4 1 1 1 1 3	d- d e-	f	4
5b	47	Green	1 5 3 1 2 3	1 3 2 1 1 1 3	1 4 2 1 1 1 3	e- e- e-	d-	3
5c	52	Green	2 3 3 2 2 1	1 4 3 2 2 1	4 2 2 2 2 1	b- e e	d	5
6a	21	Blue-green	1 4 1 1 1 2 1 1	2 2 1 2 1 2 1 1	1 1 3 1 1 1 1 3 1	e e e	g	5
6b	28	Blue-green	3 3 1 1 1 3 2	2 2 1 2 1 2 3 1	1 1 3 1 2 3 1	d- d e-	f	4
7a	10	Blue	1 3 3 1 1 4	1 1 2 3 1 1 3	1 2 2 3 3 1	g f- e-	i	6
7b	38	Blue	1 1 5 1 3 2 1	2 1 3 2 1 1 3 1	2 2 3 1 3 2 1	e- e- e	e	4
8a	19	Violet	2 4 1 1 4 1	2 3 1 1 1 4	1 2 3 1 1 5	d- e d-	g	8
8b	11	Violet	1 4 3 1 4	1 3 3 1 1 4	1 2 4 1 1 4	f- f- f	h-	6
9	30	Red	2 2 3 1 3 1	2 2 3 1 1 1 2 1	3 2 2 1 1 1 2	d- e d	e-	3
10	35	Green	2 2 3 2 1 3 1 1	3 1 1 4 4 1 1	3 2 1 1 4 1 1	e- e- e-	e	-1
11	1	Blue	9 6	9 6	8 6	i i i	i-	1
12	68	Orange-yellow	2 1 1 4 1 2 1 1	1 3 1 1 2 3 1 1	1 4 1 2 3 1 1	e e e	e	-5
13	13	Blue-green	1 6 1 1 3 2	2 5 1 2 1 2 2	2 1 4 1 2 2 3	e- e e-	h	8
14	22	Purple	2 6 3 1 1	2 6 1 1 3	1 2 3 1 1 1 1 3	e- e- e-	f-	3

contrast or clearness of the colored and uncolored pictures are equal for any given brightness of the uncolored light, for all values of brightness of the uncolored light less than this, the colored picture will seem to have greater contrast or clearness.

The columns under "Average" in the Table give the average brightness, clearness and contrast of all the observers for both trials, the two trials being weighed equally though there were more observers at the first than at the second. The second trial, as may be seen, indicates a value of brightness, clearness and contrast lower than the first by approximately 20%, 15% and 30%. Part at least



Units of B-T arranged in a circular spectrum.

of this difference can be accounted for by a difference in the two machines (which were interchanged for the second trial) so small as to be detectable only by the averaging of a number of readings such as those described.

As far as can be seen clearness and contrast follow brightness quite closely, instead of contrast being considerably greater in the colored picture, as reported in the last Transactions. This would lend some strength to the belief that dye does not act uniformly on

a photographic film having different quantities of silver at different points, but that the dye collects around the silver particles.

In the column headed "Transmission" are given the values graded by letter of the transmission fraction given in the second column, and under B-T the difference between the average brightness, as judged by the picture on the screen, and the transmission—i. e., the brightness as measured by the flicker photometer. The units are approximately 10% of the larger value (one-third the difference between any letter and the next in order). These values of the differences are shown very roughly in the accompanying figure. The spectrum is arranged in a circle, the ends being brought together so that the violet fades into the red as the red fades into the orange.

Though far from perfect in their agreement, the points indicate a fourfold difference of brightness as compared on the screen between yellow and violet of equal brightness as measured by the flicker photometer. Also there seems to be a suggestive symmetry about the orange-yellow, blue-violet diameter.

In conclusion, the Committee wishes to show a few representative slides to indicate not only the method of the experiments, but also the difficulty an observer experiences in determining the effect of color on brightness, as well as clearness and contrast. Though in some instances the preference is quite marked it does not necessarily follow, as is shown in the Table, that a second trial of the same slide will produce the same impression.

The Committee does not regard the conclusions indicated above as in any sense final, but the problem is one of such complexity, and the time available for the tests so short, that progress must necessarily be slow.

W. E. Story, *Acting Chairman.*

Reducing the Fire Hazard in Film Exchanges

By George A. Blair

WITH the rapid growth of the use of motion pictures in the amusement, educational and scientific fields, there has been a corresponding increase in the amount of film in storage and commercial circulation, and while regulations were adopted with respect to transportation and safeguards including the use of fire-proof booths and licensed operators in its projection in the theatres, comparatively little attention was given to the matter of proper and adequate protection in the ever increasing number of film exchanges, from which distribution is made to the motion picture theatres.

This situation, as far as the exchanges are concerned and particularly in the earlier days of the industry, may be attributed to the necessity of securing convenient and available premises, without sufficient consideration being given to the fact that the storage of film introduced a fire hazard, more especially where large quantities of naked film were being handled.

A relatively small number of the many connected with the motion picture industry in its various branches are familiar with the manufacture of the film or have understanding of its physical properties, more especially with respect to its behavior when subjected to fire. Under the circumstances, it will be recognized that carelessness and indifference in the handling were constantly in evidence, yet in spite of this condition serious fires with attendant loss of life were a comparatively rare occurence.

Practically all motion picture film used in the amusement or theatrical field has a nitro-cellulose base or support on which the sensitive or photographic emulsion is coated. This base or support is composed of a cellulose nitrate of a low degree of nitration. It is readily inflammable and one of its interesting characteristics is that, chemically speaking, sufficient oxygen is present within the structure of the material to help support combustion, or to continue decomposition without additional outside air.

When ignited and burning in a liberal supply of air, film burns rapidly with a yellow flame and very little smoke, but if there is a limited supply of air it will often decompose without flame but with the evolution of a dense, whitish-yellow gas, which latter phenomenon is called decomposition.

One of the first serious film fires occurred on September 7, 1909, in a film exchange located in the Ferguson Building, Pittsburgh, where the breaking of an unprotected extension electric light bulb set fire to a naked reel of film within a vault which contained about 185 reels. The burning reel was thrown out of the vault to an adjoining room and the door closed but other reels within the vault became ignited. There was no vent or pressure relief leading out of the vault, so that the gases of decomposition were formed

under pressure and forced out around the door cracks to adjacent rooms. The mixture of gases with the air caused a violent explosion in these rooms, while the vault remained intact with the door closed. On later investigation it was found that the reels within the vault had undergone decomposition, leaving only a carbonacious skeleton which retained very closely the original form of the rolls.

This unusual explosion called for an immediate and thorough investigation. Since the action of the fire and methods of combatting it were not understood, an almost exaggerated fear of the hazard involved in this type of business was created.

As part of this investigation, a study of the nature of the gases of decomposition was made by the Explosive Division of the United States Geological Survey. The result substantiated previous investigations made of the flameless decomposition of celluloid; namely, that the gases consist of variable quantities of such gases as carbon monoxide, carbon dioxide, hydrogen, nitrogen, oxygen, N_2O_4 and N_2O_5 together with tarry matter. It was found that if decomposition occurred under pressure, the percentage of hydrogen and carbon monoxide was high, thus giving a greater probability of an explosive gas mixture with air. Under ordinary pressure, however, the hydrogen and carbon monoxide are present in lower percentages. It was then first realized that a pressure relief opening is absolutely necessary in storage vaults, and that any explosions which may occur in connection with the storage of film are gas explosions. Motion picture film itself, contrary to an erroneous popular idea, does not and will not explode. Its danger lies in its proclivity to decompose at a temperature slightly over 300° F. and to continue decomposition without the aid of oxygen from the air.

The need for standard and effective means for the prevention and combatting of film fires was seen. No general attempt had previously been made to draft regulations for governing the handling and storage of inflammable motion picture film. As aforestated, there had been but few fires with an extremely small loss of life, but the hazard was recognized, and the Spring of 1915 saw the beginning of experimental tests which were to serve as a basis for future standards of fire protection for film.

The test at the Universal Film Manufacturing Company plant at Fort Lee, N. J., to determine the proper size of vent for film storage was immediately followed by a series of tests conducted by the Eastman Kodak Company to ascertain the effectiveness of automative sprinkler protection in vaults, and proper methods of storing film.

The details of these tests are of interest, but it is probably more advisable at this time to give merely the results, which may be briefly summarized as follows:

First: Automatic sprinkler protection is absolutely essential in film storage vaults and cabinets. Each standard vault of 750 cubic feet should be equipped with 12 sprinkler heads, for only large quantities of water instantly applied can provide the

necessary cooling effects and prevent the possible formation of explosive gas mixtures.

Second: Ample pressure relief openings or vents are necessary to prevent the building up of pressure in vaults and cabinets. The area of these vents was determined at 70 square inches for each 100 reels of film or at 1,400 square inches for each standard vault of 750 cubic feet, actual storage capacity.

Third: The subdivision of the film racks into sections by asbestos board or heat insulating material is an added safeguard, or check, to the rapid spread of fire.

Fourth: All film, whether in vaults or in rooms, should be kept in individual containers made of a heat resistive material, and with corrugated top and bottom. These containers are round; about 10½″ in diameter and 1¾″ thick.

Fifth: These individual containers must be stored on edge, that is, in a vertical position. This will insure proper sprinkler operation, the corrugations permitting the free passage of water between the containers, thus checking the spread of the fire.

Sixth: All film, when not actually being worked upon, should be kept in storage vaults or cabinets.

With the results of these experiments as a basis, and with the knowledge and conviction that motion picture film fires could be controlled, the National Fire Protection Association drew up regulations governing the handling and storage of nitro-cellulose motion picture film, recommending their adoption as standard. These regulations have undergone but few minor changes and are now published in booklet form by the National Board of Fire Underwriters and recommended by them to be used as a basis for municipal ordinances.

For the most part, such fires as occurred were caused through carelessness and the neglect of precautionary measures and a general lack of understanding as to the proper methods of handling and safeguarding the film.

The motion picture interests, realizing that fire protection was economically advisable and necessary as a matter of safeguarding life and property and that neglect or failure to observe standards of fire protection would have a detrimental reaction on the entire industry, appointed, through their organization—the National Association of the Motion Picture Industry—a special committee on fire prevention.

Another fire, which unfortunately again occurred in a Pittsburgh film exchange on January 7th, 1919, and in which a number of lives were lost, provided a concrete impetus to the carrying on of this new work. The regulations recommended by the Fire Protection authorities were endorsed and the entire association pledged itself to the active improvement of existing conditions in film exchanges throughout the country and to the instruction of those immediately responsible for exchange management.

The Eastman Kodak Company offered assistance in the furtherance of this program by providing men, especially trained for this

particular type of work, who made thorough inspection of every exchange in the United States and Canada, and in each case submitted reports containing positive recommendations for improvement to the producers operating these exchanges. In these tours of inspection, which covered 56 cities, approximately 1,500 inspections were made in about 600 different exchanges. Each exchange received at least two visits and most of them were inspected three times. That there was great need for better methods of fire prevention in all localities was forcibly demonstrated, and, also, that to provide adequate protection in these exchanges, the majority of which had substandard equipment and were improperly housed, would require a wasteful and unsatisfactory program of expenditure. This situation being drawn to its attention, the National Association of the Motion Picture Industry entered upon a broader plan of constructive activity and, through its film exchange building committee, has been actively engaged in promoting the erection of new and adequate film buildings, complying fully with the fire prevention regulations and providing ideal arrangements for the conducting of an exchange business.

As a direct result of this work, buildings in Kansas City, Atlanta, Pittsburgh, Buffalo and Cincinnati have been completed and are occupied exclusively by film exchanges, and exchange buildings are in the course of construction in Cleveland, New Haven, Omaha, Montreal, San Francisco and Los Angeles, while active promotion is being carried on in Philadelphia, Chicago, Milwaukee, St. Louis, Indianapolis, Denver, Salt Lake City and other cities.

At a regularly called meeting of the Distributors' Division of the National Association of the Motion Picture Industry held in New York on April 23rd, 1920, the following resolution was passed:

> *Resolved*, That we affirm our pledge of cooperation with and support of the work of the National Fire Protection Association and the recommendations of that body for the handling and storage of motion picture film as adopted by the National Board of Fire Underwriters.

This resolution, together with a report of the activities of the Fire Prevention Committee, was read at the 24th Annual convention of the National Fire Protection Association held in Chicago on May 4th, 5th and 6th, 1920, and was received with unqualified approval by that body.

In connection with the new Kansas City building referred to, undoubtedly most of you have learned of the recent fire in this building. After a thorough investigation had been made, it was conclusively shown that the fire was entirely due to violation of minor structural details and, most important of all, to the absence of automatic sprinkler protection, which was in course of installation at the time of the fire. Had it not been for the major structural features of the building, which proved their worth in an excellent manner, the results would in all probability have been much more serious. The fire was confined to a very small portion of the

eleventh and twelfth floors, being held by fire doors and partitions. The damage to the building was almost inconsequential, or in the neighborhood of $10,000.00.

The Eastman Kodak Company stands ready and willing at all times to act in an advisory capacity on plans and specifications of prospective film exchange buildings without cost to the builders; also to make inspection of buildings as construction progresses and prior to occupancy, and should it be found that the plans as recommended have not been followed, to point out the facts in written report to both owners and lessees.

It is believed that with such cooperation, the exchanges will be properly constructed and equipped and, with the addition of good housekeeping and maintenance on the part of the tenants, that the possibilities of fires will be reduced to the minimum with absolute certainty of quick control, should they, by any chance occur.

Reflection Characteristics of Projection Screens

By Lloyd A. Jones and Milton F. Fillius

WHEN it is considered that the enjoyment of the entertainment offered in the motion picture theater depends almost entirely upon the visual organs, it will be recognized that the importance of providing conditions which will result in the least possible visual fatigue to the audience cannot be overestimated. There are many factors which deserve the consideration of the motion picture engineer in order that the maximum of visual comfort may be obtained, among which may be mentioned the proper distribution of the interior illumination, the elimination of excessively bright surfaces in the field of vision, and the proper adjustment of the screen brightness. The fact that the attention of the audience must remain fixed for long periods of time upon the projected picture makes it of utmost importance that the projecting system be so adjusted that the screen brightness is neither so high as to cause visual fatigue due to glare, nor so low as to throw an undue burden upon the retinal accommodation.

The optical properties of the surface upon which the motion picture is projected determines to a great extent the ultimate efficiency of the entire installation, and hence should receive due consideration at the hands of the motion picture engineer. While there is no doubt that this is recognized, and that considerable improvement in the quality of projection screens has been made in recent years, it seems that the subject has been approached largely from the practical standpoint and that little quantitative data are available relative to the optical characteristics of the materials used so extensively at the present time.

In view of this deficiency, it seemed worth while to examine critically the reflection properties of the large number of commercial screens on the market. From the data obtained by such examination, it will be a relatively simple matter to choose the most efficient screen surface for a given installation. An examination of the commercial screens obtained showed a remarkable variation in reflection characteristics, ranging from surfaces which almost completely diffuse the incident light to screens of a very specular nature, having very high reflecting powers on the projection axis and very low values in directions departing by relatively small amounts from the normal. When the question of adapting the screen to the shape of the room in which it is to be used is considered, it will be seen that it is quite hopeless to obtain in all cases the maximum efficiency with a screen of fixed characteristics.

For instance, if the length of the room is large relative to its width, a screen of the completely diffusing type is very wasteful of light, and the necessary screen brightness can be obtained over the required angle by the use of a screen which reflects a large proportion of the incident light within a comparatively narrow angle.

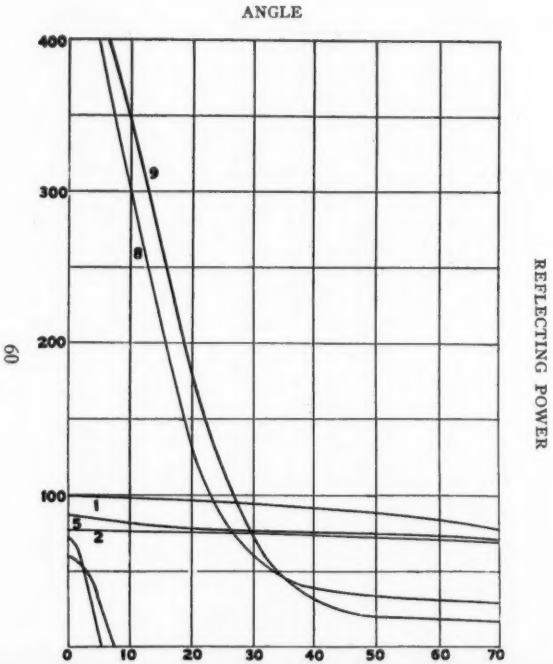


Fig. 3. Distribution Curves of Miscellaneous Surfaces.

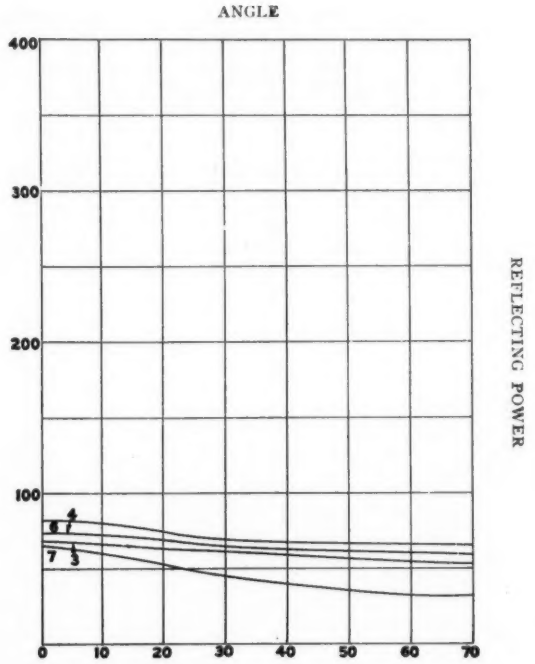


Fig. 4. Distribution Curves of Miscellaneous Surfaces.

thus permitting the use of lower amperage in the arc of the projection machine. On the other hand, a screen of the specular type installed in a room where the length is relatively small as compared with the width will not be found satisfactory. Since the screen in this case may be viewed by a part of the audience at a relatively large

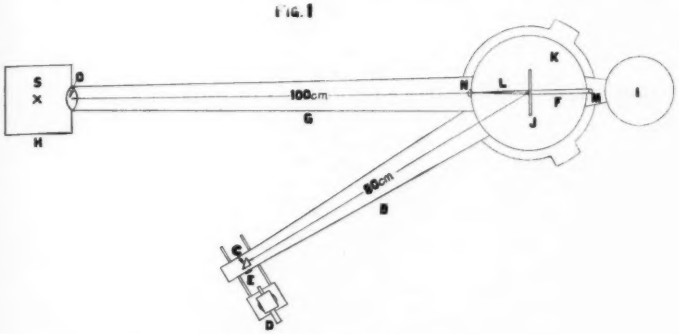


Diagram of Goniophotometer.

angle, it will be necessary to use a high arc current in order to make the picture of satisfactory brightness for these observers. This will result in an unnecessarily high brightness on the axis of projection and may result in excessive visual fatigue owing to glare. It should be pointed out also in case the throw is somewhat short that a highly

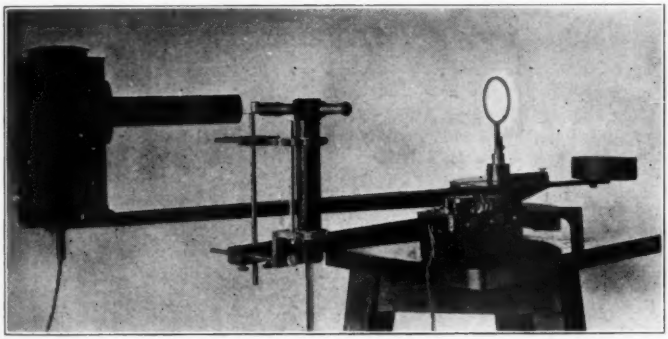


Fig. 2—Photograph of Goniophotometer.

specular screen may appear of unequal brightness when viewed from a single point of observation, since the angle of incidence varies from point to point on the screen, and that for an observer relatively near to the screen the angle of observation is not constant for all parts of the picture.

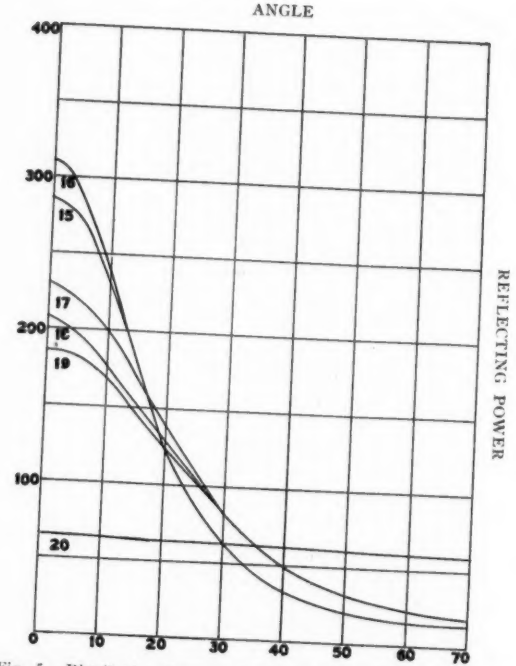


Fig. 5. Distribution Curves of Commercial Projection Screens.

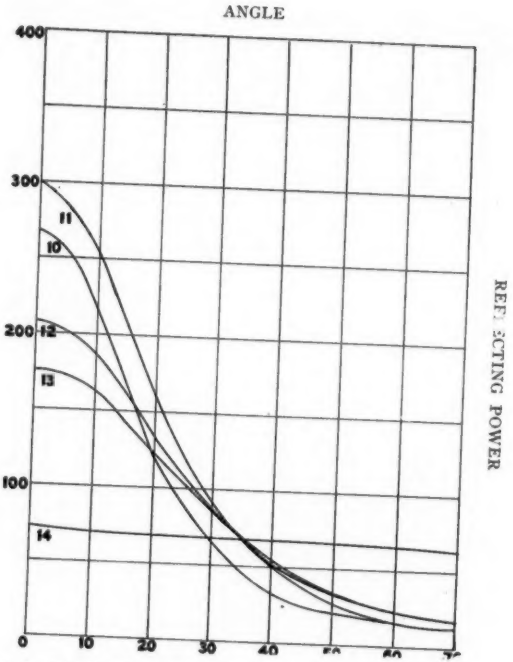


Fig. 6. Distribution Curves of Commercial Projection Screens.

Fig. 5. Distribution Curves of Commercial Projection Screens.

Fig. 6. Distribution Curves of Commercial Projection Screens.

The problem of measuring and specifying the characteristics of diffusing surfaces has been treated by Dr. Nutting[1] and results on several characteristic surfaces are given. The data given, however, relate almost entirely to miscellaneous surfaces, only two commercial screens being included among the materials examined by him. Recently a paper by Charles W. Gamble[2] has appeared in which he deals with the subject in a more or less general way. Here again the data given relate largely to surfaces which are not extensively used in the motion picture theatre. His results are of a qualitative character and the highest efficiency obtained is that of a mirror ground on the front surface.

Method and Apparatus

The method adopted in this investigation is quite similar to that used by other investigators and consists in measuring the brightness of the surface under examination when viewed at various angles of observation, the illumination being incident normally upon the screen surface. The incident illumination in this case was approximately parallel light, such conditions being considered as more closely approaching those existing in practice than the method used by Dr. Nutting in which case a completely diffused source subtending 1/10 of a steradian at the surface was used. In order to expedite the experimental work which involved the examination of a large number of samples, a special goniophotometer was constructed. A diagram showing the essential parts of this instrument is shown in Fig. 1.

A heavy cast-iron base, *A*, supports the arm *B*, at the end of which is carried the photometric apparatus. In order that the observer and the photometric equipment might not interfere with the illumination of the sample at angles approaching closely to the normal, the axis of observation was bent at right angles by use of the total reflecting prism C. A portable photometer of the illuminometer type was mounted at *D*, and the small lens *E* placed immediately in front of this photometer permitted the formation of an image of the surface under examination in the plane of the photometer cube. In case the texture of the surface was such as to interfere with precise photometric settings, this lens could be displaced by amounts sufficient to eliminate the disagreeable surface texture. A rigid bearing *E* supported by the base casting carries a movable arm *G* on one end of which is mounted the lamp house *H*, while at the other end a counterpoise weight *I* is placed. A holder is provided for the sample at *J*, this is so mounted that it holds the surface of the samples being examined in the plane passing through the axis of rotation of the arm *G*. The circular scale plate *K* is mounted in a fixed position relative to base *A*. A pointer attached to the sample

[1]Nutting, P. G., Trans. Ill. Eng. Soc., Vol. II: 1916, p. 92.

[2]Gamble, Charles, W. B., B. J., Vol. LXVII, 1920, p. 553.

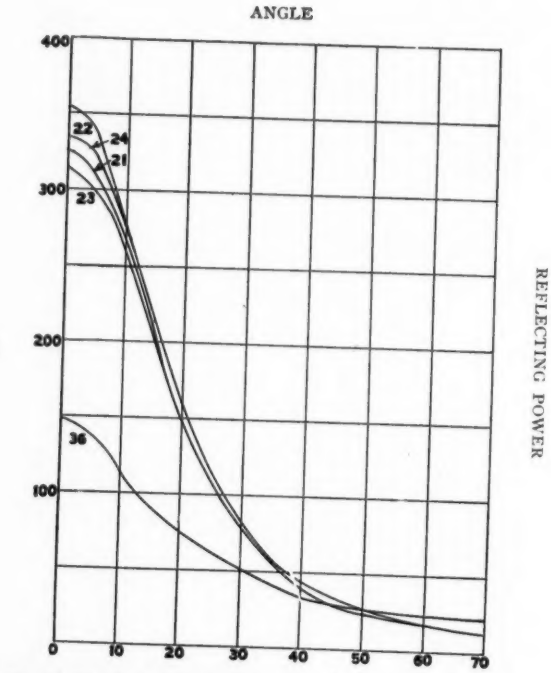


Fig. 7. Distribution Curves of Commercial Projection Screens.

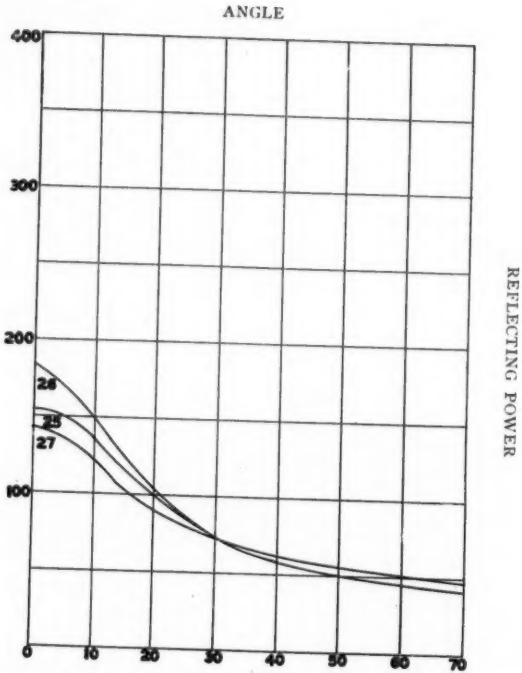


Fig. 8. Distribution Curves of Commercial Projection Screens.

holder indicates the angle on the divided circle. By means of a pin M, the sample holder can be connected rigidly with the moving arm G, so that the plane of the sample will remain perpendicular to the incident illumination for all positions, and as the arm G is rotated the angle of observation alone varies. This provides for the measurement of the surface brightness at various angles of observation and fixed direction of illumination. By removing the pin M and clamping the sample holder to the base, A, the arm G moves independently of the sample, and observations of brightness at a fixed angle of observation, but with a variable angle of incidence can be made. In the front of the lamp house is mounted a lens O of such focal length that the source S falls at its focus. Under such conditions the light incident on the sample is approximately parallel. The dimensions of importance are as indicated in the figure. It is also so arranged that the lens O can be removed and in its place substituted a disk of diffusing material such as ground pot opal glass.

The dimensions are so adjusted that the effective area of this diffusing material is just sufficient to subtend an angle of 0.1 steradians at the surface of the sample under examination. A 500-watt Mazda C lamp of the concentrated filament type was used as a source for illuminating the samples. A photograph of the apparatus is shown in Fig. 2. The voltage was precisely controlled in order to eliminate variations in brightness due to fluctuations in the line voltage. Brightness measurements were made at angles of observation from 0 to 70°. Three complete sets of readings were made by two observers on each screen, and the final result obtained by taking the average of all readings. In practically all cases excellent agreement between the individual sets of data was obtained.

The results are expressed in terms of the reflecting power of magnesium carbonate with normal illumination and observation as 100%. The absolute value of the reflecting power of magnesium carbonate is at the present time subject to some question and in view of that fact it was not deemed advisable to attempt to reduce the measurements of screen reflecting powers to absolute terms. The values given are therefore relative to that of magnesium carbonate. When a satisfactory value for this material is determined that data can then be reduced to absolute terms, if such seems desirable.

Materials Examined

Orders for samples of the commercial projection screens were placed with practically every maker whose advertisement could be located in the trade journals. Response was not obtained from all makers, but a fairly representative group of samples was received. The standard samples were prepared by mounting a piece of the projection screen 8 inches square on a thin metal plate, thus insuring flatness of the sample under examination. In addition to the commercial screens mentioned, several miscellaneous surfaces of interest were examined.

Fig. 8. Distribution Curves of Commercial Projection Screens.

Fig. 7. Distribution Curves of Commercial Projection Screens.

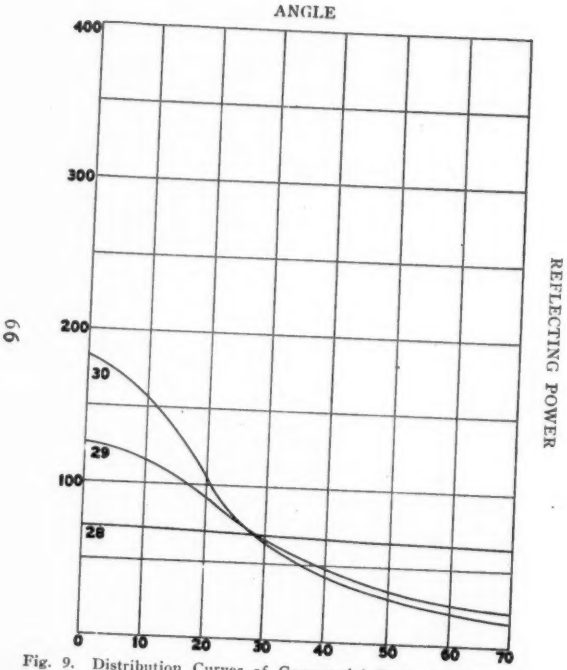


Fig. 9. Distribution Curves of Commercial Projection Screens.

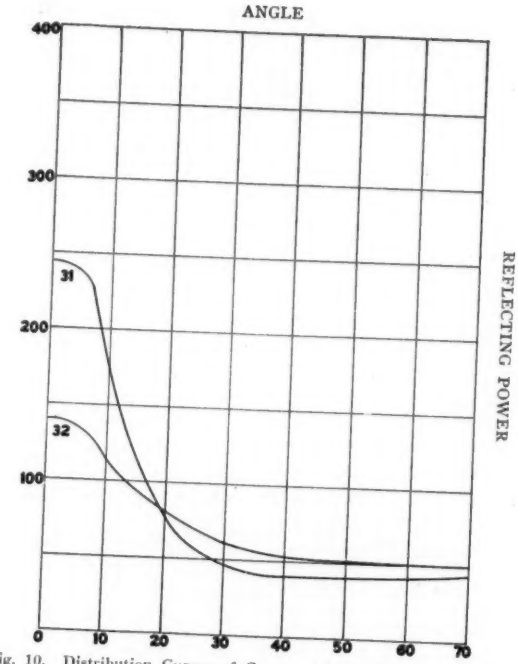


Fig. 10. Distribution Curves of Commercial Projection Screens.

Fig. 10. Distribution Curves of Commercial Projection Screens.

Fig. 9. Distribution Curves of Commercial Projection Screens.

TABLE 1

No.	Class	Name	Texture	Color
1	C	Magnesium Carbonate	Smooth	White
2	C	Opal Glass	Smooth	White
3	C	White Blotting Paper	Smooth	White
4	C	Photo Stock Plain	Smooth	White
5	C	Photo Stock Coated	Smooth	White
6	C	White Drawing Paper	Smooth	White
7	B	Sandblasted Aluminum	Smooth	Metallic White
8	A	Sandblasted Mirror	Smooth	White
9	A	Focus Screen and Mirror	Smooth	White
10	A	Superlite	Coarse Grain	Metallic White
11	A	Special	Coarse Grain	Metallic White
12	B	Green Back	Fine Grain	Metallic White
13	B	White Back	Fine Grain	Metallic White
14	C	Plain White Coated	Smooth	Yellow
15	A	Imsco Silver No. 1	Coarse Grain	Metallic White
16	A	Imsco Gold No. 1	Coarse Grain	Metallic Yellow
17	A	Imsco No. 2	Coarse Grain	Metallic White
18	A	Imsco No. 3	Medium Grain	Metallic White
19	B	Imsco No. 4	Fine Grain	Metallic White
20	C	Imsco White Muslin	Smooth	White
21	A	Minusa A	Medium Grain	Metallic White
22	A	Minusa B	Coarse Grain	Metallic White
23	A	Minusa C	Coarse Grain	Metallic White
24	A	Mazda-Lite	Fine Grain	Metallic White
25	B	Idealite-Grade 1A	Fine Grain	Metallic White
26	B	Idealite-Grade 1B	Medium Grain	Metallic White
27	B	Idealite-Grade 2	Fine Grain	Metallic White
28	C	Dalite Crystal White	Smooth	Blue Green
29	B	Dalite Gold Fibre	Fine Grain	Metallic Yellow
30	A	Dalite Silver	Fine Grain	Metallic White
31	A	Argus Crystal Bead No. 1	Medium Glass Beads	Yellow
32	B	Argus Crystal Bead No. 2	Fine Glass Beads	Yellow
33	B	Mirroroid	Fine Grain	Metallic White
34	A	Gold Ring	Smooth	Metallic Yellow
35	C	Half-tone	Smooth	White
36	A	Aluminium Paper	Smooth	Metallic White

In Table I is given a complete list of the materials measured. The surface of the magnesium carbonate sample (1) was prepared by carefully scraping a block of the material with a steel straight-edge. The opal glass (2) was of the best quality obtainable for uniformity and whiteness, and the surface was carefully ground. The white blotting paper (3) was of the ordinary commercial quality used extensively in photographic work. The photographic stock (4) was a sample of uncalendered and uncoated material. No. 5 was of the same material but treated with the ordinary baryta coating. The drawing paper (6) was the commercial grade of Wattman's hot pressed. Sample No. 7 was prepared by sandblasting a sheet of aluminum. No. 8 was made by sandblasting the front surface of an ordinary plate glass mirror. No. 9 consists of a screen made by superposing a sample of the material such as is commonly used as the focusing screen in photographic apparatus upon the surface of an ordinary plate glass mirror.

The commercial screens examined are also listed in Table 1, beginning with sample No. 10. In the name column is given the trade name applied by the manufacturer to the screen. In the "texture" column is a qualitative statement of the character of the surface, while in the "color" column is a qualitative statement of the color. The terms used in specifying texture and color are very general in nature, no precise quantitative measurements being made of these

characteristics. An examination of the characteristics of these screens shows that they can be roughly grouped into three general classes which may be specified as follows: Included in Class C are those screens which give almost complete diffusion of the incident light. Class A includes those which reflect a large proportion of the incident light within a very narrow angle, and very little light at the greater angles. Class B includes the screens which are intermediate between the extremes represented by Classes A and B. It should be understood that the line of demarkation between these three classes is not distinct but that such classification is entirely arbitrary and made only for the purpose of practical convenience.

TABLE 2

MISCELLANEOUS SURFACES

No.	ANGLE									
	0	5	10	15	20	30	40	50	60	70
1	100	100	99.9	98.0	96.9	94.9	92.4	89.5	84.8	78.8
2	77.1	77.1	76.0	76.0	74.8	73.7	73.7	72.6	70.5	68.2
3	68.9	67.9	65.9	64.0	63.0	60.8	59.7	57.2	54.8	54.2
4	73.9	73.9	71.2	70.0	67.0	65.0	63.5	62.2	61.1	58.4
5	91.1	88.0	84.9	82.5	80.5	79.3	78.7	78.7	76.9	74.3
6	82.7	82.7	81.5	77.8	74.4	72.0	69.5	63.3	67.6	65.4
7	66.3	64.1	61.4	57.6	52.4	46.5	40.1	36.0	35.3	32.6
8	473	399	297	224	121	62.0	40.2	34.2	32.0	31.1
9	460	430	373	257	176	73.3	31.9	20.5	19.0	19.4

The names specular, semi-diffuse, and diffuse may conveniently be applied in the classes A, B, and C, respectively. The indication of the class to which each screen belongs is given by the letter in the "Class" column of Table 1.

Results

In Table 2 are given the reflecting powers at the various angles of the miscellaneous surfaces examined, while in Table 3 are the detailed data relative to the reflection characteristics of the twenty-seven commercial screens examined. In order to present these data in more graphic form they are plotted as curves in the following figures, the ordinates in all cases being values of relative reflecting powers and the abscissae the angles of observation to which the various reflecting powers apply.

The sample to which the curve applies is in all cases indicated by attaching the sample number. In Figure 3 are given the curves for the mirror with the sandblasted surface, and with superposed focusing screen. It will be noted that the values at normal observation are extremely high, but that the values diminish very rapidly as the angle of observation increases. Curves for samples Nos. 1, 2, and 5 are also given in this figure.

In Figure 4 are given the curves for some of the almost completely diffusing miscellaneous samples.

In Figure 5 are the curves relating to the screens manufactured by C. S. Wertsner and Son. It will be noted that among these are found examples of all three classes.

In Figure 6 are the curves relative to the screens manufactured by the Independent Movie Supply Co. and here again we find examples of all three classes.

In Figure 7 are given the curves relative to the Minusa Cine Screens and to one of aluminum coated paper manufactured by W. G. Preddy, this latter is of the semi-diffusing type.

In Figure 8 are the curves for the Idealite screens manufactured

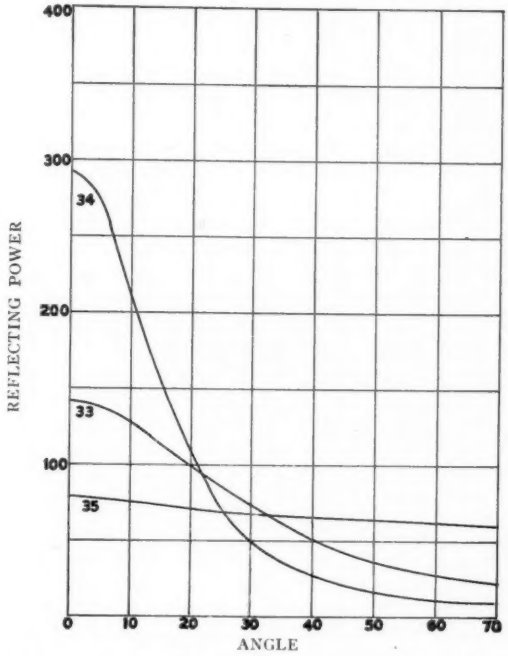


Fig. 11. Distribution Curves of Commercial Projection Screens.

by the Ludeke Screen Company. All of these fall in the semi-diffusing class.

In Figure 9 are the curves for the screens manufactured by the De Berri Screen Company, two of which are of the semi-diffusing type, while one is of the diffusing type.

In Figure 10 are the curves of the Argus Crystal Bead Screens, one of which is of the specular type and one of the semi-diffuse type. These screens are made by covering a surface of fabric with small glass beads. The reflection curves are peculiar in that the reflecting

power at 5° is but very little less than that at 0, giving a distribution curve much flatter near the normal than is usual with screens of that type.

In Figure 11 are the curves for samples Nos. 33, manufactured by H. C. Genter & Company; 34, by the Gold King Screen Company; and 35, manufactured by A. L. Raven. In this figure one screen of each class is represented.

Analysis of Results

In order to facilitate the examination of the data, it will be well to separate them into their respective classes. After careful consideration of the characteristics of the screens and of the requirements of practical use, it was decided to define the range covered by these classes as follows:

Class A includes those screens which are adapted for use in theatres where the maximum angle of observation does not exceed 30°; Class B includes the screens adapted for use where the maximum angle of observation does not exceed 50°, while the Class C screens should be used in all cases where the angle of observation is greater than 50°. The point should be again emphasized that these classifications are not rigid, but of an approximate character.

After careful consideration of the subject, it was decided that the value of the ratio of the reflecting power measured at normal observation to that measured at the maximum angle of observation

TABLE 3

COMMERCIAL SCREENS

10	268	256	215	168	120	64.8	34.3	21.8	16.8	14.2
11	300	284	255	206	167	93.9	52.2	26.5	17.0	13.3
12	208	203	188	161	134	85.0	53.3	33.0	22.4	18.3
13	177	174	165	143	122	85.9	53.0	33.0	23.8	17.7
14	72.9	72.2	70.8	70.5	69.4	68.9	68.1	68.8	67.0	64.0
15	286	273	229	173	129	66.0	33.0	21.4	15.2	13.7
16	311	288	234	180	125	66.0	35.0	21.7	15.6	14.0
17	230	220	200	171	141	83.1	47.4	29.6	20.3	16.0
18	208	197	177	152	127	80.6	47.9	34.3	24.3	19.9
19	186	183	169	146	120	79.8	47.9	31.3	22.2	17.6
20	66.4	66.3	65.2	63.6	62.4	61.0	60.4	60.0	59.3	58.9
21	326	308	270	204	157	76.0	38.6	25.7	15.0	12.6
22	355	339	274	207	149	71.7	35.8	21.7	15.0	12.8
23	315	298	256	203	151	77.9	38.9	23.0	16.1	13.0
24	334	323	276	215	160	82.9	40.0	24.5	16.6	13.8
25	154	151	136	112	97.0	75.1	56.0	52.9	47.0	43.0
26	193	187	154	124	98.5	72.2	58.4	50.2	45.2	40.9
27	142	137	122	103	93.6	76.4	63.7	55.6	50.8	46.8
28	71.7	71.7	70.8	69.9	69.2	68.6	67.1	66.0	65.3	64.8
29	126	120	116	104	90.7	68.8	47.1	34.3	26.5	21.9
30	183	172	157	134	107	65.0	42.1	28.8	20.9	16.8
31	244	240	177	116	75.6	45.5	40.0	39.6	41.7	43.7
32	140	138	113	91.4	78.6	60.9	54.8	50.8	50.4	50.0
33	142	138	129	109	99.0	73.4	49.5	35.7	27.4	22.5
34	292	271	216	160	108	49.2	28.4	17.4	13.1	9.7
35	78.6	78.6	74.9	73.3	71.1	68.6	65.3	63.9	62.3	59.5
36	148	136	111	93.6	74.1	50.2	34.1	26.5	22.6	19.5

in a particular installation would serve as the most logical criterion by which to select the most suitable screen for that particular case.

This value will then represent the ratio of the brightness of the screen as observed by a person in the center of the auditorium to that of the brightness as observed by a person occupying a seat at the side and near the front. Be keeping this ratio below a certain limiting value, satisfactory brightness will be obtained for all observers. This factor alone, however, is not sufficient for the classifying of screens according to their relative merits. The highest average reflecting power within the required angle from the normal will necessitate the least energy expenditure in the projecting system to produce a given screen brightness.

Assuming cases in which the maximum angles of observation are 20°, 30°, 40°, and 50° the values of the ratio of the reflecting power at normal observation to that at these various angles were computed for all screens and likewise values of mean reflecting

TABLE 4

CLASS A

No.	20°		30°		40°		50°	
	$\frac{R_0}{R_{20}}$	R_a	$\frac{R_0}{R_{30}}$	R_a	$\frac{R_0}{R_{40}}$	R_a	$\frac{R_0}{R_{50}}$	R_a
8	3.91	305	7.62	235	11.8	194	13.8	165
9	2.61	339	6.30	270	14.4	217	22.4	183
34	2.70	209	5.94	167	10.3	137	16.8	116
31	3.22	159	5.48	127	6.10	108	6.17	96
22	2.38	265	4.96	216	9.92	167	16.3	151
15	2.21	218	4.34	178	8.70	147	13.4	134
21	2.06	253	4.30	207	8.47	172	13.2	145
10	2.23	205	4.14	169	7.82	140	12.3	119
24	2.08	253	4.02	209	8.35	174	13.6	147
23	2.08	245	4.00	201	8.10	167	13.7	141
11	1.80	242	3.20	204	5.75	172	11.3	147
16	1.69	228	3.20	184	6.03	152	9.75	130
36	2.00	112	2.96	96.4	4.34	83.3	5.59	73.2
30	1.70	151	2.82	128	4.35	110	6.36	87
17	1.63	192	2.77	165	4.85	141	7.77	121
18	1.64	172	2.58	150	4.25	128	6.07	112

power for the same limiting angles. These values are tabulated for the Class A screens in Table 4, those for the Class B screens in Table 5, and those for the Class C screens in Table 6.

Now it seems reasonable to demand that the ratio of the brightness on the axis to that at the extreme angle of observation shall not be greater than 4.0. This value is decided upon after consideration not only of the variation in brightness as observed from various

TABLE 5

CLASS B

No.	20°		30°		40°		50°	
	$\frac{R_o}{R_{20}}$	R_a	$\frac{R_o}{R_{30}}$	R_a	$\frac{R_o}{R_{40}}$	R_a	$\frac{R_o}{R_{50}}$	R_a
12	1.55	179	2.45	155	3.91	135	6.30	117
19	1.55	161	2.34	141	3.88	129	5.95	109
13	1.45	156	2.06	139	3.34	121	5.37	106
33	1.43	123	1.93	111	2.87	99	3.97	88
26	1.96	151	2.67	131	3.30	115	3.70	104
29	1.39	111	1.83	100	2.68	90	3.68	79
25	1.59	130	2.05	115	2.75	104	2.91	94
32	1.78	112	2.30	99	2.56	89	2.76	82
27	1.52	120	1.86	108	2.23	98	2.5€	91
7	1.26	60.3	1.42	56.7	1.65	53.5	1.84	50.4

points in the auditorium, but also from a consideration of the fact that from a given point of observation the screen may appear of unequal brightness over its area. The danger of this inequality being serious increases rapidly as the value of the above mentioned ratio in reflecting powers increases. A detailed consideration of the geometry of this problem might make this point more clear, but it is not desired to lengthen this paper to such an extent as to include a complete treatment of the subject. Assuming now that we adopt the value of 4 as the limiting value of the reflecting power ratio, it is possible from the figures in Tables 4 to 6 inclusive to choose the best screen for any one of the cases considered. For instance, assuming that the maximum angle of observation is 20°, it will be noted that all values in the ratio column are less than 4. Therefore from the standpoint of distribution any one of the screens in Class A will be satisfactory for use where the angle of observation does not exceed 20°. In order now to obtain the maximum average brightness within this angle for a minimum current consumption it is only necessary to choose that screen, or screens, which shows the highest

TABLE 6

CLASS C

No.	20°		30°		40°		50°	
	$\frac{R_o}{R_{20}}$	R_{m20}	$\frac{R_o}{R_{30}}$	R_{m30}	$\frac{R_o}{R_{40}}$	R_{m40}	$\frac{R_o}{R_{50}}$	R_{m50}
6	1.10	79.8	1.15	77.7	1.19	76.1	1.30	74.6
35	1.10	75.3	1.14	73.5	1.20	71.7	1.23	70.4
3	1.09	65.8	1.13	64.6	1.15	63.5	1.20	62.5
4	1.10	71.2	1.13	69.6	1.16	68.3	1.19	67.3
5	1.13	85.4	1.15	83.5	1.15	82.7	1.15	82.0
1	1.03	99.0	1.05	97.9	1.08	96.8	1.12	95.5
14	1.05	71.0	1.06	71.0	1.07	70.0	1.07	67.0
20	1.06	64.0	1.09	64.0	1.10	52.0	1.10	54.0
28	1.02	71.0	1.03	70.0	1.04	70.0	1.07	69.0
2	1.03	77.1	1.05	76.2	1.05	75.6	1.06	75.0

value in the column marked R *a*. Now assuming a maximum angle of 30° we find that the first seven screens are excluded since the ratio of normal to extreme reflecting power is greater than 4. Beginning with No. 11 we may then choose the screens showing the highest average reflecting power for the range 0 to 30°. When the maximum angle of 40° is considered we find no screen in Class A which does not exceed the limiting value of 4 for reflecting power ratio. We therefore turn to Table 5, and there find that all values of the reflecting power ratio are less than 4. We may therefore select from Class B that screen which has the highest reflecting power for the 0-40° range. In case of the 50° limiting angle, three of the Class B screens are automatically excluded, and it is only necessary to select from the remainder the one having the highest average reflecting power for the 0-50° angle.

It should be emphasized that this method of selecting a projection screen recognizes only the reflection characteristics of the screen and further that these are considered only from the standpoint of intensity. In many cases it will be found that several screens are practically of equal value when judged by this criterion. In such cases other considerations such as color, surface texture, durability, and other physical properties may be the deciding factors in the final choice. Many of the screens examined show excellent characteristics and while the screen makers are to be congratulated on many of these screens it is to be hoped that this critical examination of screen characteristics may stimulate them to greater efforts and to the production of even better and more efficient surfaces for this purpose.

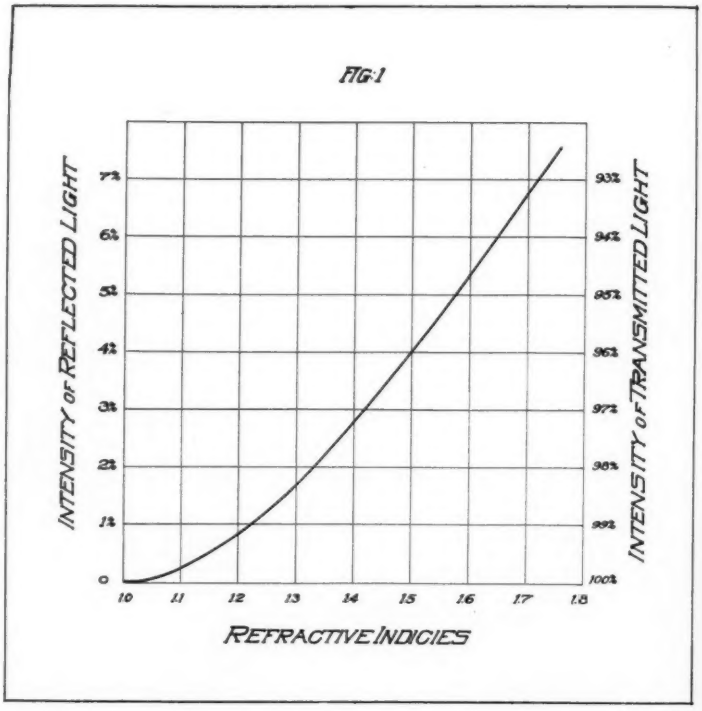
Absorption and Reflection Losses in Motion Picture Objectives

By Hermann Kellner

LOSSES of light in projection lenses may occur for two reasons: First, Geometrical arrangement of power, distances, etc., sizes of lenses;

Second, Physical reasons, material the lenses are made of, conditions of glass surfaces, etc.

It is with the physical conditions that we are concerned with



now. When light strikes a border surface between two optically different media, for instance, water and air, a part of this light enters the water and illuminates the bottom of the containing vessel, while another part is reflected back into the air. So is part of the sunlight which strikes a window passed into the room while another part is reflected upon the street. The ratio of the reflected to the transmitted light depends upon the refractive indices of the media as well as upon the finish of the surface.

The greater the difference in refractive index, the more light is reflected and the less light is transmitted. If we have two horizontal surfaces, side by side, one formed by water, the other one of glass, and observe the amount of sunlight reflected, we will find the glass surface to be a more efficient reflector than the water surface and at the same time the illumination inside the water greater than inside the glass.

The amount of reflected light changes also with the angle of

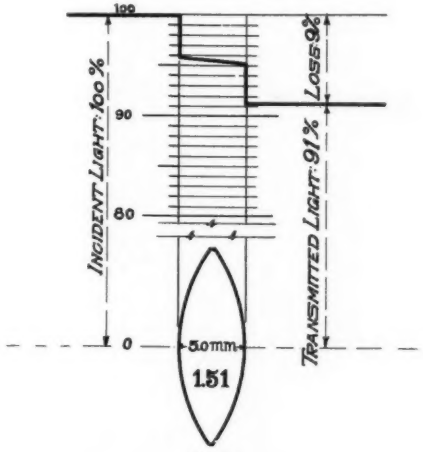


Fig. 2

shows the curves for the loss of light in a double convex lens of refractive index 1.51, at and between the surfaces.

incidence. The more nearly perpendicular the light source stands over a surface, the less light is reflected. If we now consider that the more light there is reflected at the surface, the less of it passes through the surface, it is evident that the conditions for passing the greatest amount of light become most favorable, when the refractive index is as low and the angle of incidence as small as possible. We may remember that the angle of incidence is the angle between the direction of the ray of light and the perpendicular at the point of incidence, and that therefore the angle of incidence is the smaller, the nearer the ray of light is perpendicular at the point of incidence.

The action of a lens depends on the refractive index of the material it is made of. To get any lens action at all, the refractive index has to be greater than that of air, which is 1.00. Therefore we shall always have a certain loss of light when light passes through a lens surface. The amount of this loss is determined by means of a formula which was derived by Fresnel, the famous French

mathematician and optician. He found for perpendicular incidence the following equation:

$$I - I^1 = \left(\frac{n-1}{n+1}\right)^2$$

where in I is the amount of light falling upon the surface,

I^1 the amount of light transmitted by the surface, and

n the refractive index of the medium.

The difference $I - I^1$ is the loss of light at the refracting surface.

The curve in Fig. I shows for refractive indices varying from 1.0 to 1.8 the intensities of the reflected and transmitted light.

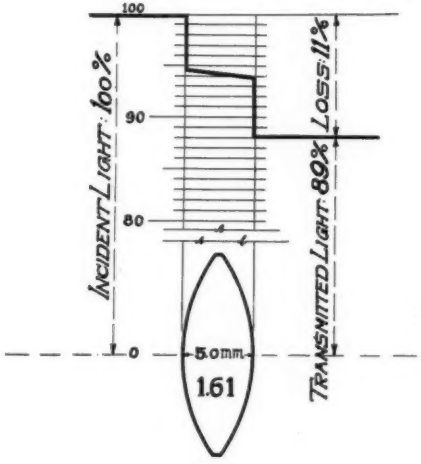


Fig. 3

shows the curves for the loss of light in a double convex lens of refractive index 1.61, at and between the surfaces.

The variation of the loss of light with the angle of incidence may be seen in the following table. It is assumed that the light in unpolarized, an assumption which satisfactorily represents practical conditions.

Angle of incidence	*Crown* 151	*Flint* 1.61
0°	Loss 4.13%	Loss 5.46%
30°	" 4.28%	" 5.64%
60°	" 9.08%	" 10.69%
70°	" 17.29%	" 18.97%
80°	" 38.92%	" 40.30%
90°	" 100.00%	" 100.00%

The refractive indices of the glasses as used in projection lenses vary from about 1.51 to 1.61.

The loss of light per surface for perpendicular incidence if for
Refractive index 1.51 amounts to 4.13%
Refractive index 1.61 amounts to 5.46%

The angle under which light rays strike the surfaces of a projection lens varies from 0° to about 30° and fortunately for the simplicity

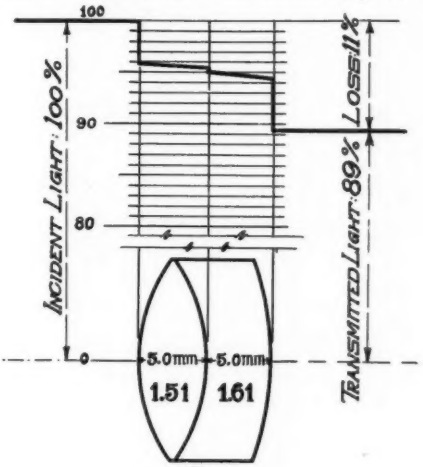


Fig. 4
shows the curve for the loss of light in a cemented doublet consisting of a lens with refractive index 1.51 and another lens with a refractive index 1.61, at and between the surfaces.

of this discussion the variation of the loss within these angles is negligible as may be seen in the table. We may therefore say that the loss of light per surface on a

Crown Glass lens.....4.2% and on a
Flint Glass lens.....5.5%

The refractive index of Canada Balsam is approximately equal to that of Crown glass and therefore if lenses of 1.51 and a Flint lens of 1.61, are cemented together, the loss by reflection at a cemented surface is very much smaller, than at surfaces bordering on air. Since the refractive index of Canada Balsam is practically the same as that of Crown glass no loss is incurred at the transition from the Crown glass into the layer of Balsam, while between the Balsam and the Flint glass the difference amounts to only 0.1 which means an almost negligible loss.

For a number of glass surfaces in air of about the same loss by reflection the total loss may be arrived at by using the compound interest formula. If the loss, p, for one surface is represented as a fraction of the initial intensity, the loss for k surfaces will be $1 - (1 - p)^k$.

The loss by *Absorption* depends on the nature of the glass and on the thickness of the lenses. Good Crown glass will not absorb more than 0.5 to 1% per centimeter thickness, while Flint glass of

1.61 refractive index, will run a little higher, from 1% to 1.5% per centimeter.

The lighter varieties of Flint glass, of indices between 1.54 and 1.61 have absorptions between these limits, while the absorption of bad glasses runs as high as 3 and 4% per centimeter.

If we take a Crown glass lens of an average of 5 mm., the losses by reflection and absorption total up as follows:

100% 95.8% 95.3% 91.3%

or about 9% per lens.

With a Flint lens of 1.61 we obtain the following data:

100% 94.5% 94.0% 88.8%

or about 11% per lens.

For a cemented lens consisting of cemented crown and flint elements we find

100% 95.8% 95.3% 95.2% 94.2% 82.2%

or again, a total of about 11%.

Figures 2, 3 and 4 represent these conditions graphically.

In this way it is very easy to form an opinion on the losses by reflection and absorption in any combination. In general it is safe for an estimate to assume the loss per single lens or per combination of cemented lenses, as they occur in projection lenses, to about 10%.

If the workmanship and material are approximately the same, and no difference exists in the geometrical arrangement, diaphragming, etc., of the lenses, the amount of light passed through is very nearly the same in all lenses that have the same number of reflecting surfaces.

A very important factor for the performance of a lens is the condition of the surfaces. Scummy and dust-covered lenses give gray pictures with no contrast, just in the same way as photo lenses will not take snappy pictures if dispersed light from finger-marks on the lens is allowed to reach the plates. It is therefore of the utmost importance that in comparative tests the lenses should be clean.

I may mention here shortly that there exists a condition of lens surfaces which is helpful in the way of reducing the amount of reflected light and increasing the amount of transmitted light. Such surfaces have an iridescent appearance which is caused by chemical action. It had been discovered accidentally in process studios that such lenses allowed shorter exposures and upon investigation, it was found that actually the amount of transmitted light had been increased. Unfortunately such action takes place for the most part on glasses which have comparatively great absorption co-efficients and are not generally used for projection lenses, and therefore, any thoughts of helping the matter by these means will probably have to be dismissed. The amount of loss by such treatment can be reduced by as much as 50%.

In conclusion I may say that all the statements made above are borne out by practical tests not only in comparatively simple combinations like projection lenses, but also in the most complicated apparatus like range finders, submarine periscopes, etc.

The High Power Arc in Motion Pictures

By Preston R. Bassett

ONE of the greatest developments in Military illumination during the war was the High Intensity Arc. In order to compete with the new methods of warfare both our Army and Navy found it necessary to demand searchlights of an intensity which had been considered unattainable. The ordinary carbon arc, such as had been used in searchlights for many years, could not be forced by any means to meet this urgent demand for more powerful searchlights. It was only the development of a new source of light which could fill this need. As was the case in many engineering branches of the service, necessity was the mother of invention, and so a new source of light was perfected and introduced into the searchlight field during those remarkable years of the war when a new development would be in common use by the Army or Navy before the public had even heard of its invention.

This new light source, which is known as the High Intensity Arc, made an advance in searchlights which was actually revolutionary since it increased the efficiency of searchlights by 500% at one step. By the end of the war, both our Army and Navy and many of our Allies were equipped with searchlights of this high power type, and the old carbon arc searchlights which were the best available only a few years ago, are now fast becoming obsolete.

High power arcs may be classified broadly as electric arcs, having positive craters with intrinsic brilliancies greater than can be obtained with pure carbon positive craters. Before explaining in detail the method of operation of a high power arc, it is necessary for us to appreciate the limitations of the pure carbon arc. Practically all of the light from a pure carbon arc emanates from the incandescent positive crater. Incandescence is a function of temperature and, therefore, in order to obtain a light source of maximum brightness, a substance must be used which can be maintained at the highest possible temperature. As is well known, carbon has the highest melting point of all substances, and for this reason it has been used in all cases where light sources of greatest brilliancy have been desired. In an electric arc between pure carbon electrodes, the surface of the tip of the positive electrode is maintained at a temperature of over 3,700 degrees Centigrade. The carbon surface, when heated to this point, gives forth about 160 candle-power for every square millimeter of its surface. This brilliancy we may call the maximum obtainable from any solid by temperature radiation. When such a carbon arc is forced by, let us say, doubling the current, the brilliancy of the crater is not increased proportionately as might be expected. Instead the carbon is consumed at a faster rate without any material increase in the temperature of the crater. It is, therefore, perfectly useless to force a carbon arc beyond a certain point

where the crater is practically at the volatilizing point of carbon and has, therefore, reached its maximum theoretical efficiency.

In searchlight work, the only practical way of increasing efficiency was to increase the intrinsic brilliancy of the source of light. Since this was impossible by using solids, an investigation was made of vapors and gases. There is no known limitation to the temperature to which vapors may be heated, but on the other hand, vapors and gases do not obey any known laws of radiation such as apply to incandescent solids. In general gases and vapors are very poor brightness producers when compared with incandescent solids. For

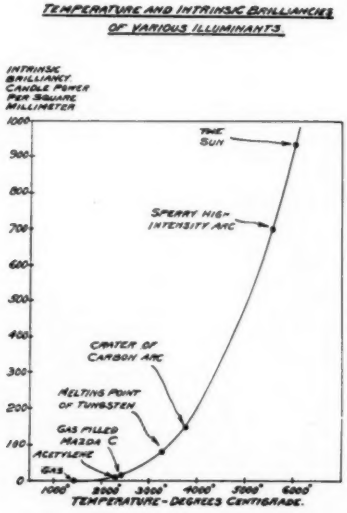


Fig. 1 — Curve showing the comparative brilliancy of common illuminants.

instance, the arc flame in a pure carbon arc consists of vapor at a temperature greater even than the temperature of the positive crater and yet, it gives a brilliancy of only about one candle power per square millimeter, as compared to the 160 c.p. per sq. mm. given by the incandescent crater. Luminescent or light-giving vapors have long been used as light sources of exceptional efficiency, but they had never even been considered as competitors with incandescent solids when intrinsic brilliancy was required. The mercury vapor arc, the yellow and white flame arcs and the magnetic arc are all among the most efficient of light sources, but their intrinsic brilliancies are very low, all of them being less than 5 c.p. per sq. mm. In the high power arc, vapor has been made use of for the first time as a light producer of excessive brilliancy. The special vapor-producing materials are placed entirely in the core of the positive

carbon. This carbon is so constructed that when burned at the proper current, it forms a deep crater. It is usually rotated to keep this crater uniform. The special flame material enters the arc entirely from the bottom of this deep crater where the impregnated core is exposed to the arc. The negative carbon is so arranged that the negative flame sweeps across the positive crater in such a manner that the light-giving vapor from the positive core is confined and compressed in the crater. By properly confining this vapor in the crater by means of the negative flame, the brilliancy of the vapor is very greatly increased, and instead of obtaining brilliancies in the neighborhood of 5 c.p. per sq. mm., we obtain brilliancies ranging

Fig. 2—The 150-Ampere High-Intensity Arc. This photograph shows clearly the excessive brilliancy of the vapor bulging out in front of the positive crater, and also the action of the forcible negative arc flame in pressing it back and confining it practically to the crater.

from 500 to 900 c.p. per sq. mm. These are figures which were hitherto unknown on earth. The sun at high noon is the only other source which man has seen that can approach such a brilliancy. The noon day sun has an intrinsic brilliancy of about 920 c.p. per sq. mm. Figure 1 shows graphically how this new type of arc compares in brilliancy with all of the brightest illuminants known. It is evident that by utilizing concentrated and compressed vapor of spe-

cial materials at temperature of the electric arc, a new form of illuminant has been introduced with many new and very interesting characteristics. It was the remarkably high intrinsic brilliancy of this new arc which gave it its value in searchlight work, but in the application of this arc to other uses other equally important properties of this light have been controlled and accentuated so that the light is also proving revolutionary in other fields.

The motion picture industry is without doubt the greatest light-using industry in the country and the demand of this industry for

Fig. 3—Photograph taken 2½ miles from a High-Intensity Arc in the Sperry 60" Searchlight. An idea of the power and actinic value of the light may be obtained by comparing the dark lower right-hand portion of the arch which is illuminated by the street-lighting unit only fifteen feet from it.

more light has been continuous and insistent with the advance of the art. There are two main departments of lighting in the motion picture industry; the producers' lighting, which consists in lighting the studios for photographing the pictures; and the exhibitors' lighting, which consists of the light for projecting the pictures on

the screen. These two fields are very different and each has required a special development and adaptation of the high power arc.

The arc was most readily adapted to studio lighting. In this field the high intensity arc, better known as the Sunlight Arc, met with the immediate favor of producers and camera men, who found that its unique qualities opened up entirely new fields of photography. The use of a single lighting unit having an intensity of over 100,000 c.p. made it possible to invade with the motion picture camera places which were hitherto inaccessible. The largest ball rooms and theatre interiors in the country have been illuminated sufficiently to take excellent motion pictures with from two to four of these powerful units. This one use in itself is a tremendous saving in expense to the producer who is enabled for the first time to go out of the studio to any desired interior location with the same freedom that he has been used to in going out on exterior locations. This single use has made the light indispensable to producers.

In the studio sunlight arcs are of great value in illuminating the large sets. When placed at a height of about 20 feet above a set, the amount of actinic light on the set is sufficient to give good

Fig. 4—The skyline of New York taken with one High-Intensity Arc, 150 Amperes. Both searchlight and camera were two miles from the buildings. The picture was obtained by keeping the camera open while the searchlight beam was moved over each building. The lights in the foreground are on Brooklyn Bridge.

photographic results more than 60 feet from the unit without the use of lenses or mirrors. The open arc used in this manner as a flood-light has been found valuable in high-lighting a large set and giving a predominant direction to the main lighting, thus avoiding the disagreeable cross shadows which are so noticeable when several smaller units are used in place of one large unit.

Another use of the open flood light is the illumination of back-drops or scenery outside of windows or doors in interior sets. It is universal practice in taking artistic interiors to have windows, doors or arch-ways through which can be seen daylight or sunlight. To properly produce this effect, a great intensity of light outside of these openings is essential, since the interior is already illuminated to a

high level and the exterior must be enough brighter than the interior to give the impression of looking out into daylight. Frequently, sunlight as well as daylight, is required to enter through the opening. It is then necessary to direct the open flood light so that it falls through the opening and makes a patch of light on the wall or floor. Excellent results are obtained with the direct arc for these sunlight effects, and since the source of light, which measures only 5/8" in diameter, is so small for its intensity that sharper shadows can be obtained with it than can be obtained with any other source in the studio.

In exterior night work the open flood is invaluable to light any large scene. In street night scenes the lights are located at positions and heights which make the scene appear as though lighted by regular street lamps. Two or three of the arcs as open flood lights will illuminate a section of a street, large enough for several hundred actors to take part in such scenes as raids, riots, etc.

Aside from the advantages of intensity and concentration of

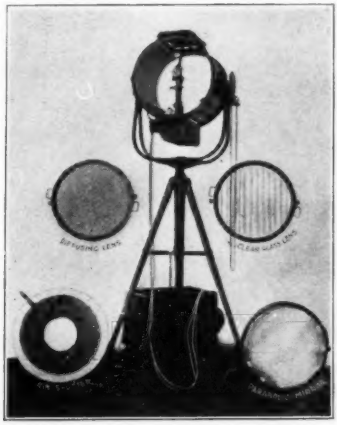


Fig. 5—The High-Power Arc Unit with its accessories. This unit consists of one High-Intensity Arc consuming 150 Amperes.

the high intensity arc in photographic work, several other properties of this arc are worthy of mention. In the first place the confining of the bright vapor in the intensely hot crater makes the light very steady and free from flicker. Small disturbances do not affect the light or change its intensity in the manner that is so noticeable in the small flaming arcs where the light emenates from the arc flame between the eletrodes instead of from a deep crater. Another reason for the extreme steadiness of the light is the fact that the high current used (150 Amperes) makes an arc which has considerable

inherent stability due to what might be called its own inertia. The advantages of a steady light of high candle power are universally appreciated by Motion Picture photographers.

Another feature which is partly responsible for the unusual efficiency of this unit is that nearly 80% of the total amount of light from the arc falls in the hemisphere toward which the positive carbon is facing. This useful distribution of the light is due to the fact that it is emitted from the crater, hence when the arc is viewed from some point where the crater face is not visible the candle power is extremely low. The Sunlight Arc is the first illuminant for general studio lighting which has taken advantage of this restricted distribution of light within the zone to be illuminated. Other sources of light all have a uniform light distribution in all directions, and hence must use some form of reflector in order to reflect the 50% of the light which falls away from the scene, back onto the scene. Such

Fig. 6 (left)—A snapshot taken in an office with one High-Intensity Arc Unit with its diffusing door. Note that the light on the wall and on the papers on the desk is actually brighter than the direct daylight through the windows.

arrangements are not only inefficient, but are compromises since half of the light is direct and the other half is indirect and diffused. The high intensity arc on the other hand is capable of producing either all direct or all diffused light as desired, depending on whether the crater is pointed directly toward the scene or toward some diffusing medium or reflector.

We have spoken of the quantity of light from this arc, another and equally important aspect is the quality of the light. Photographers agree that the ideal light for photography is sunlight and north sky-light. The ideal artificial illuminant for photography is that one which most nearly approaches daylight in quality. Daylight is not highly colored, it is usually referred to as pure white, but in comparison with most artificial lights it would be called slightly bluish in hue. The high intensity arc is very similar in quality of

light to bright daylight, that is, the combination of sunlight and skylight, it is clean bluish white in color. The arc, however, although nearly identical with daylight in the visible spectrum has the advantage over daylight in the ultra-violet or actinic portion of the spectrum. The light from the sun loses from 50 to 75 per cent of

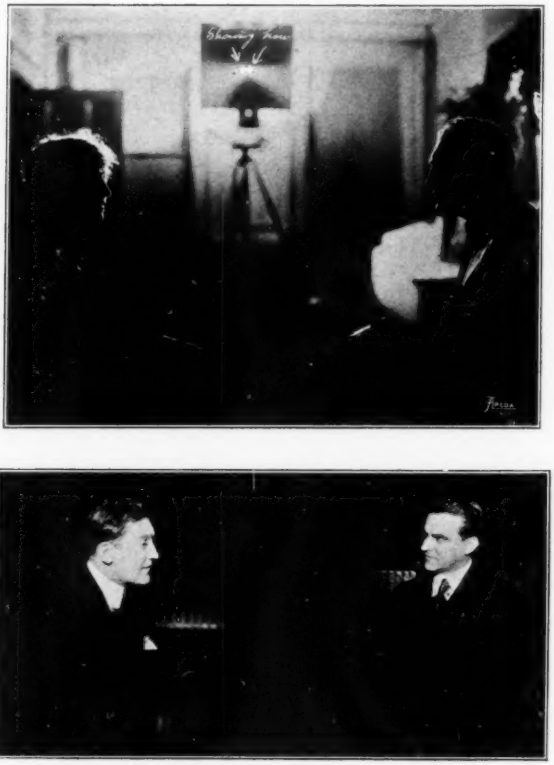


Fig. 7 (below)—Two snapshots showing the use of the direct rays from the arc passing through two small holes in a metal screen giving spot-light effects without lenses. One photograph (lower) shows full front lighting and the other back lighting.

its actinic value in penetrating through the 100 miles of the earth's atmosphere. The high intensity arc, however, loses none of its actinic value on the scene since it has no appreciable amount of atmosphere to penetrate. It has been found that for the same amount of illumination on a subject, the High Intensity Arc is more actinic than

daylight. The quality of the light has made it indispensable in the newer branches of motion picture photography. The uniform brilliancy throughout the entire spectrum gives the ideal light for motion pictures in natural colors. The actinic value of the light has made it possible to take excellent interior photographs with the ultra speed camera, taking pictures at the rate of 160 per second.

Figure 5 shows the High Intensity Arc Studio unit with the accessories which make it possible to produce either hard or soft light of almost any intensity. Some of the uses of the open arc without the accessories have been already described. The following outline of uses with the accessories will give an idea of the flexi-

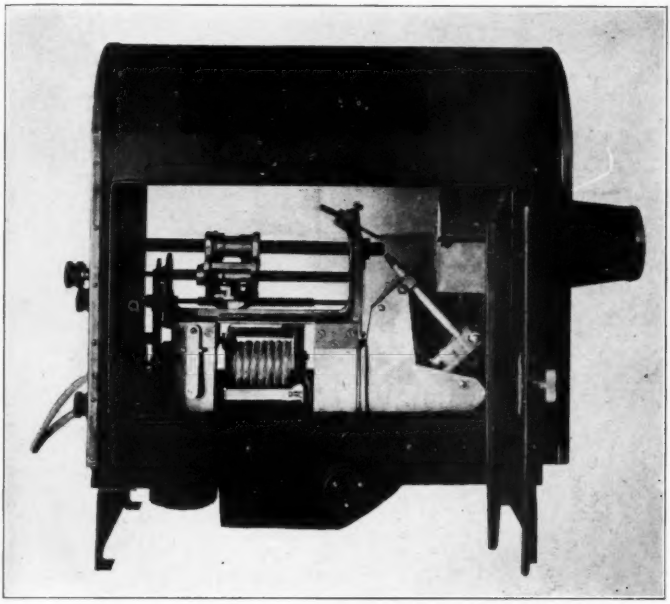


Fig. 8—The High-Power Automatic Lamp mechanism and house. Designed for 50 or 70 Amperes, direct current.

bility which can be obtained with a unit having one very concentrated and intense source of light.

When it is desired to limit the angle through which the open flood light spreads, the Iris shutter is used. By closing down the shutter the lighted area is decreased in size but the intensity remains the same. When the Iris Shutter is nearly closed the flood light then appears as a spot light since the light has a spread of only a few degrees. This is, in reality, a spot light without a lens. It can be used for special effects. This spot light also has an advantage

not obtainable in any lens spot light, that is, it can be spread from an angle of a few degrees up to an angle of over 150 degrees without decreasing the illumination. In lens spotlights the illumination decreases as the square of the increase in angle of spread.

Another arrangement of the Studio Outfit is with the diffusing front door. The purpose of this accessory is to make possible a softer light than that obtained by the direct arc.

The open arc casts very sharp edged shadows which are much desired when simulating sunlight or in special silhouette effects, but many uses demand softer shadows, especially in illuminating interior scenes. The diffusing door not only spreads the light very evenly

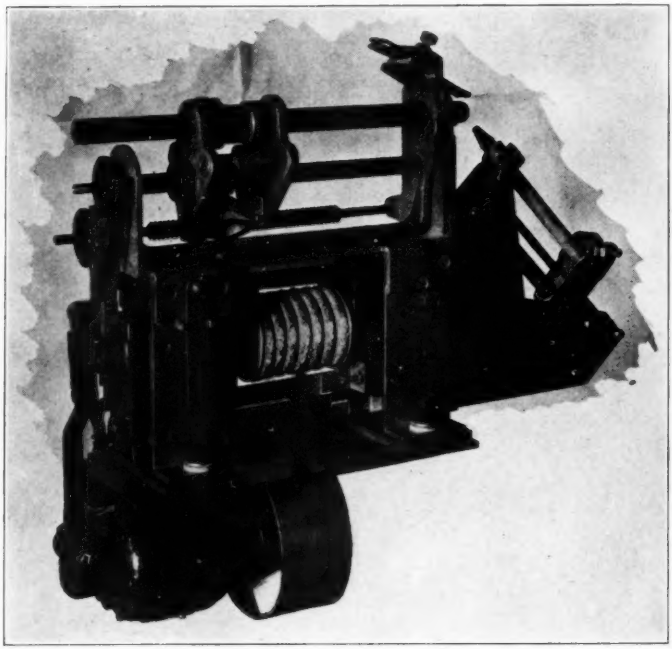


Fig. 9—High-Power Automatic Projector Lamp, showing motor and automatic features.

in all directions, but it acts as though the source of light were now two feet in diameter instead of 5/8" diameter as it is with the open arc. Shadows cast by this arrangement are, therefore, more blended and softer.

The most usual use of this arrangement is to intensify the diffused light from a certain direction on a medium or small sized scene. It is used to best effect with other units such as banks of

mercury vapor arcs. The banks supplying the general illumination from several directions and the diffused studio arrangement intensifying this from one direction causing a more artistic effect by accentuating lights and shadows.

When the Iris Shutter is used with the diffusing door the effect is different than in the case of the open arc. Instead of changing the angle of spread, it changes the intensity of the light without affecting its distribution. Hence closing down the Iris with the diffusing door causes the light on the whole scene to fade away from full intensity to darkness. This arrangement gives the camera man a unit where he can adjust the strength of his light on the scene between wide limits and may cause the light to fade away or increase perfectly uniformly while taking pictures.

The parabolic silvered glass mirror is furnished with the studio outfit for special effect work and long range work. With the arc facing the mirror a beam is produced which measures in the millions of candle power. It is entirely too powerful to be used at short ranges except for special work. One successful short range use of this beam is in the production of an actual visible beam such as a moonbeam or sunbeam entering a window and falling across a room. It is possible to actually register the path of the beam on the motion picture film due to the reflection of light by the dust particles in the room.

The parabolic mirror is also used on large scenes when in addition to the general illumination a spot light is needed on some special part of the scene, such as the dancers in a Cabaret scene or any theatrical effect in a large set. In exterior sets this beam has been used with great success in night effects such as lightning, searchlight effects, etc. Good motion picture photography has been taken at night on exterior location with the lighting unit over one quarter of a mile from the camera and the scene.

The extreme flexibility of the high intensity arc unit with its accessories has given the directors and camera men a new tool. New applications and new effects are being produced regularly as the possibilities of this source of light with its reflectors and diffusers are becoming better understood by those who are using it.

Adapting the high power light to motion picture projection has presented many difficulties and it has only recently been satisfactorily accomplished. It must be realized that up to the present time nothing but incandescent solids have ever been used for sources of light in motion picture projection whereas in the studio lighting vapor sources, for instance, mercury vapor arc and flame arcs have been in general use since the first days of motion pictures. The high power arc for projection had to be so steady and free from flicker and all disturbances that it would give as constant and steady a light as the incandescent sources in general use. This has necessitated the development of new carbons and the design of a special mechanism for burning these carbons for projection purposes. Figure 8 shows this mechanism in its lamp house. The positive carbon is horizontal and lies in the optical axis of the condenser lenses. The negative

carbon is positioned at a steep angle to the positive carbon so as not to interfere with or cast any shadow on the optical system. Arcs with the carbons in these positions have been commonly referred to as "right angle arcs." Right angle arcs have not met with favor in the past and have not been used in any of the large motion picture houses. The causes for the failure of the right angle arc have been numerous. All previous right angle arcs have had carbon electrodes and such arcs have a strong tendency to hiss and to become uncontrollable at currents greater than 40 amperes. Moreover, such arcs have been very sensitive to charges in position of the electrodes and means of controlling the carbon feed had never been developed to a point of accuracy necessary in a right angle arc. Furthermore, if the positive carbon contains a soft core, as is general practice, this core in burning exposes a dark spot at the center of the positive crater, which in turn causes a lack of light on the center of the aperture plate and film. It is quite generally admitted that from the point of view of optical efficiency, the right angled arc is the best, since with this arrangement, the condenser lenses gather the maximum possible light flux. In the Sperry Automatic Projector Lamp all of the above mentioned defects have been overcome by entirely novel means and the gain in optical efficiency has been even greater than expected.

In this new automatic lamp a special cored carbon is used as the positive electrode. This carbon forms a deep crater which is kept filled with the luminescent vapor, several times the brightness of the surrounding shell, so, therefore, instead of having the center of the crater a comparatively dark spot, it is, on the other hand, the brightest part of the crater. In order to keep this form of arc burning in a perfectly steady manner, the positive crater has to be held within 1/32″ of the same position at all times, and the electrode is slowly rotated in this position to keep the crater burning evenly. A novel method of controlling the position of the positive crater has been developed in connection with these arcs. It is an electrical method which takes advantage of the ionized condition of the arc flame and the air immediately surrounding it. A piece of copper insulated from both positive and negative is positioned with its end just at the point over the positive electrode where it is desired to hold the crater. This copper third electrode is connected through a small magnet to one side of the main circuit. When the arc is burning, the arc flame sweeps up past the end of this third electrode. As the crater burns back to this electrode, the arc flame approaches nearer and nearer to the third electrode until the electrode is in a region of ionized air sufficient to carry enough current from the arc through the third electrode and the magnet to cause the operation of the magnet armature which in turn feeds the positive carbon. As the positive carbon is fed forward, the arc flame is also carried away from the third electrode and the current through the third electrode immediately ceases to flow. This form of control has been developed to a point of complete reliability and an accuracy of crater position better than 1/32 on an inch. The advantage of this in the projector

lamp is very evident since the crater is held positively in all three directions; up and down and laterally, it is fixed by the electrode holder which is in line with the optical axis. In the direction of the optical axis it is held accurately at one point (the desired focal point) by means of the third electrode. The negative carbon is fed by means of a coil in series with the arc. This series coil feeds the negative carbon either forward or backward by means of pawls and ratchets, maintaining a constant current at all times. This current control also automatically strikes the arc by feeding the negative carbon up into contact with the positive when the switch is closed and then drawing back until the arc length is such that the current is the desired amount. Two carbon trims have been developed and standardized, one for fifty amperes and the other for seventy amperes.

These lamps have been tried out within the last six months in many of the largest motion picture houses around New York City and the results have been not only surprising but very consistent under all conditions. One theatre having a screen 24 x 20 feet and 170′ throw, was obtaining exactly 2-foot candles on the screen by means of the regular 70 ampere carbon arc. We installed the Sperry Lamp on the same projector and obtained 6.2 foot candles on the screen or three times the screen illumination with exactly the same current. At another theatre, having a screen 21 x 17 ft. with a 200 ft. throw, we found that they were obtaining 4.1 foot candles with a 120-ampere carbon arc. Installing the high-power lamp on the same projector, 7.5 foot candles was obtained at 70 amperes. This is almost equivalent to doubling the screen illumination with a saving of 40% in current. At the Capitol Theatre, with a screen 18 x 15 ft. and a 212 foot throw a screen illumination of 5.5 foot candles was being obtained from a 125-ampere arc. The Sperry lamp on the same projector gave 8.8 foot candles at 75 amperes, which result is very consistent with the foregoing results at the other theatres.

The following table summarizes these results. The last column in this table which is headed lumens per ampere reduces all of the figures to a common basis for comparison. This figure is obtained by multiplying the foot candles on the screen by the number of square feet in the screen, giving the lumens, and dividing the total lumens by the current in amperes. The resulting figure is a direct measure of efficiency of the complete optical system, irrespective of length of throw and size of screen.

	Direct Current, Amperes	Size of Screen	Area of Screen, Square Feet	Illumination Foot Candles on Screen	Lumens on Screen	Lumens per Ampere
Carbon Arc, A.....	70	24x20	480	2.0	960	13.7
High Intensity, Arc..	70	24x20	480	6.2	2976	42.5
Carbon Arc, B.....	120	21x17	357	4.1	1464	12.2
High Intensity, Arc..	70	21x17	357	7.5	2677	38.2
Carbon Arc, C.....	125	18x15	270	5.5	1485	12.0
High Intensity, Arc..	75	18x15	270	8.8	2376	32.0

It will be readily seen that the well standardized optical arrangements as now used in all large theatres give a limiting efficiency with the carbon arc of about 12 to 14 lumens per ampere. The only method of increasing this efficiency with the standard optical system is by means of a brighter and more efficient source than the carbon arc and this has been accomplished in a striking way by means of the new high-power arc which is giving consistently about three times the lumens per ampere on the screen. With this light increase available to exhibitors, there should be many advancements and improvements in large house projection. It will be possible to use wide-angled screens in the larger sizes instead of being compelled by the lack of available light to use the narrow-angled metallized surface screens. Also it is possible by means of this new lamp to project satisfactory pictures on screens larger than has heretofore been practical. This may increase the size and depth of the future large motion picture houses, if an increased seating capacity is still desired. It will certainly make the outdoor moving picture in amusement and public parks much more popular, since in this field the smallness of the screen and the lack of sufficient illumination has been the greatest drawback.

But the most urgent need for more light on the screen at the present time is caused mainly by the increasing density of the films which are now being released by all of the largest producers. In addition to the extreme density of the artistic feature films now being produced, more than half of these films are also toned or tinted. This reduces the screen illumination still further by an amount varying from 40 to 90 per cent. Projection equipments which could project very satisfactorily the motion picture play of four years ago, cannot give the same satisfaction with recent films without at least doubling the available light. The high power arc arriving as it has at just about the same time as the dense artistic tinted feature film will solve the problem of maintaining satisfactory projection in the large houses by more than doubling the available light and also by rendering the color tinted films in brilliant true colors, due to the pure white quality of the high power arc.

Design of Power Plant and Electrical Distribution in Large Studios

By Jac. R. Manheimer

NOTE—The following paper covers a description of the power plant and electrical distribution equipments designed and installed in the new Eastern Studios and Laboratories of the Famous Players-Lasky Corporation in Long Island City, N. Y., and the Studios and Laboratories of the Fox Film Corporation in New York City.

SYNOPSIS

By Jac. R. Manheimer

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I. General description of buildings.

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VI. Telephone systems.

VII. Fire alarm and watchman's systems.

VIII. Laboratory.

In modern studio design, the greatest problem before any studio engineer or architect is undoubtedly that of adequate and proper facilities for lighting the various stages. The arrangement of stages and the locations of lights is generally known to be the most uncertain feature in the operation of a studio. This condition requires the utmost flexibility. In the control of the studio lighting in large projects such as the Famous Players-Lasky and Fox Film Studios, the arrangement of the electrical equipment is a matter of prime consideration.

In the early days of the motion picture studio, the lighting equipment was arranged in a manner similar to that of the legitimate theatre stage and very little thought was given to the entirely different character of the work executed in the studio. In the beginning this make-shift was not so noticeable, due principally to the fact that the industry was "feeling its way" and had not yet started to broaden out into an established industry requiring intensive production. Studios of more than one or two stages were unknown and probably unthought of. Instead of a number of different pictures or scenes being filmed at the same time in the same building, usually one complete picture or serial was finished before another one was begun. There was employed during this time only one director. The studio itself was still in an experimental and development stage, as were other branches of the industry.

In studios where sunlight was not used, cables were strewn haphazardly across the floors and hung or festooned across the structure of the building from a central switchboard to the various stages for supplying the floor and overhead lamps. The lamps were controlled by men stationed both at the lamps and at the switchboard. The men operating this equipment received signals and instructions, from the director or camera man, which were supposed to be executed properly, promptly and in synchronism. As happened quite frequently the misunderstanding of the signal by a single man meant a retake of the entire scene, loss of time for players, directors and stage hands. Strange to say, many of these conditions have carried over to a fairly recent period, and it is only within the last two years that any great strides have been made in the efficient and proper electrical distribution and control of artificial lighting for studios.

The method of arranging the lights to be controlled by the director or camera man promptly, efficiently and without errors, was one of the first questions to be considered.

A problem which presented itself in the two mammoth studios to be described in this paper, was the design of a suitable equipment which could be used by from eight to eleven directors simultaneously working on adjacent stages, without interference with each other.

This paper describes only generally the various considerations and engineering problems which went into the design of many of the special features in these projects and is not intended to present the electrical engineering of the problem with its many technical calculations and computations leading up to the results obtained. The

paper is illustrated with photographs taken during the progress of construction and upon completion of some of the work.

FAMOUS PLAYERS-LASKY STUDIO AND LABORATORY

I. General Description of Buildings.

The Famous Players-Lasky Studio building is located at Pierce Street, 6th and 7th Avenues, Long Island City, and is a reinforced concrete structure containing upper and lower studios each measuring approximately 230 feet in length by 120 feet in width. The clear height of the upper studio is approximately 40 feet and of the lower studio approximately 20 feet. Around the studio section of the building the various offices, carpenter shops, prop rooms, scene

Figure 1—Studio and Laboratory Buildings, Famous-Players-Lasky Corporation, Long Island City.

docks, etc., are located. Located on the second floor in the rear half of the building are the men's and women's dressing rooms, all of which are provided with daylight in addition to artificial light. In order to provide daylight for some of the inside dressing rooms, an ingenuous saw-tooth roof construction was employed, as is illustrated in Figure No. 1.

The main studio is covered over by a series of iron grating footwalks which are approximately on the same level as the roof of the dressing room and executive sections of the building. The arched

truss part of the roof provides working space over the main studio, space for monorail system carrying the overhead lamps, overhead switchboard equipment, etc., as will be subsequently described. The two-story building shown to the left is the Laboratory Building owned and operated by the Famous Players-Lasky Corporation, also of reinforced concrete fireproof construction.

II. Power Plant.

The Famous Players-Lasky Studio is supplied with 7,600 volts, 60-cycle, alternating current, by the local lighting company. The Famous Players-Lasky Corporation has a wholesale contract with the Lighting Company for high-tension current, based on an average maximum demand for a 30 minute period during peak load and it is hoped that the cost of current will be brought down to approximately 2 cents per K.W. hour when the studio is in full operation. The

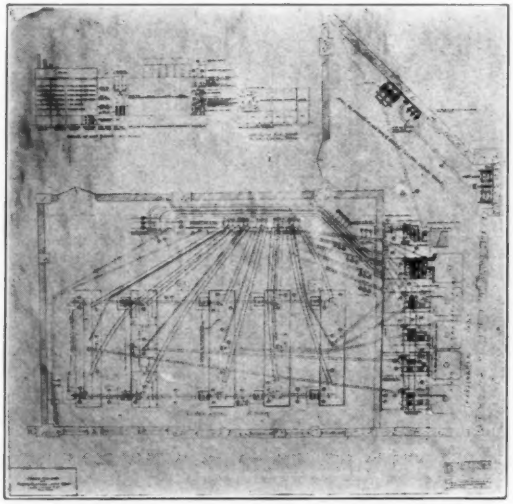

Figure 2—Detail plan of Generator Room and Transformer Vault.

7,600-volt lines are brought into the building underground to the lower level of a high-tension vault, as shown in Figure No. 2, through the Lighting Company's primary switches, recording watthour meters and demand meters and from there run to the consumer's main-line oil switch and sub-oil switches and transformers. The transformer equipment is used for general house lighting and power. The 7,600-volt high-tension service is run through the various disconnect and oil switches directly to 435 H.P. synchronous motors, each direct connected to two 150 K.W. generators.

Each one of these units of which there are three at the present time, has a direct current capacity of 300 K.W. and designed to

supply 3-wire system at 250/125 volts. The motor generators installed are of the three-unit type arranged with two generators mounted on a common shaft on either end of the driving motor. This type of apparatus has been found most suitable for supplying direct current in studios. It is generally known that the three-wire system of distribution is the most economical, but that the possibilities of unbalancing such a system in a studio are very great. With the standard type 3-wire generators as are ordinarily furnished for commercial work, the percentage of unbalancing of load on either side of the three-wire system is rarely if ever permitted to be more than 25%, which is the maximum capacity of the special balancing coils, balancer set or compensating taps inside of the machine. However, in studios, the nature of the load is such that the percentage of unbalancing is very high and sometimes reaches as much as 100%. There is no commercial type three-wire generator made which will operate under these conditions and the universal practice, therefore, now seems to lean towards the application of three-unit sets where the two generators on the same set are connected in series to obtain the Edison 3 to 2 wire system in identically the same manner as was employed by the large central stations in the early days of the Edison three-wire system. The neutral or middle leg of this system is connected to the tie between the positive lead of the one machine and the negative lead of the other.

A very interesting paper* was contributed by one of our members describing the various advantages obtained by the use of this type of apparatus.

A feature of this installation, which is rather unusual, is the application of the 7,600 volts direct to the synchronous motors without interposing "step-down" transformers.

With this arrangement transformer core losses and transformer difficulties are eliminated as well as the loss of valuable space, bulky and expensive oil switch equipment and the original investment of transformers with maintenance, depreciation and interest items charged against them.

So far as safety of operation of the high-tension motors is concerned, ample protective devices are provided, guarding against accidental or intentional contact with the live parts of the high-tension equipment. The connection to each and every piece of high-tension apparatus is intercepted by a double throw disconnect switch with lower jaw grounded. When it is necessary to perform work or make repairs on any part of the equipment, the high-tension disconnect switches on this circuit are thrown into the lower jaws. This opens the supply circuit and connects the equipment to the ground, thereby insuring the repair man or operator that the apparatus upon which he is to work is of the same potential as the ground and also at the same time dissipating all static or condenser charges.

The arrangement of supplying the various 7,600-volt motors on

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*Campe, H. A. Transactions, October, 1919.

the motor generator sets is shown diagramatically in the plan view of Figure No. 2, and it will be noted that the only high-tension connections coming into the generator room are those running directly into the generator pits under the 435-H.P. motors. These connections are all thoroughly insulated and protected so that workmen in the generator pits cannot make accidental contact with any of the high-tension connections. In addition to this safety feature, a complete network of grounding conductors has been run under the floor of the transformer vault and generator room, consisting of No. 4/0 cables laid in the concrete with taps and connections to ground shafts

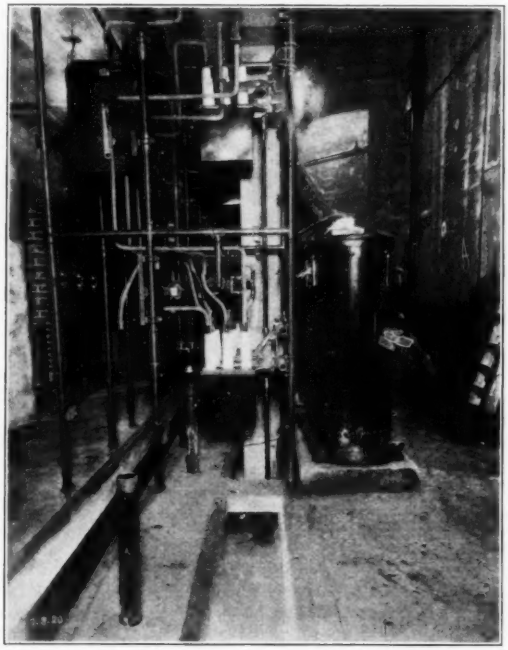


Figure 3—Lower level of high tension vault during construction.

sunk 18 feet to permanent moisture. These grounding shafts have been spotted around the equipment on about 10-foot centers, so that the failure of any one ground will not interfere with the effectiveness of the rest of the grounding system.

The plan in Figure No. 2 shows five auto transformers used for starting the 435-H.P. motors on the five motor generator sets. The present equipment consists of only three units, but all underground conduits and foundations have been prepared for two additional sets.

Figure No. 3 is a photograph of the lower level of the high-tension vault during construction, showing on the right the auto

transformers for starting the high-tension motors and the oil switches and high-tension disconnect switches mounted on pipe frame construction. The special double floor construction designed to receive the various oil switch operating mechanisms, thereby leaving the floor of the transformer vault free and clear of all obstructions and projections to trip over, is shown in the illustration. Figure No. 3 shows the openings in the floor without the trench plates in place. To the left of the photograph can be seen the rear of the high-tension control board which is mounted into the wall separating the transformer vault from the generator room. The various oil switch operating rods are seen dropping to the lower level of the double floor and rising at the oil switches. The high-tension service is tapped off and feeds through all the equipment shown in Figure No. 3, directly to the motors.

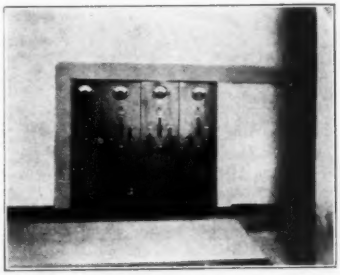


Figure 4—7,600 Volt dead front flush type control board.

A noteworthy feature of this installation is the arrangement of the wires from the various instrument transformers which are run inside of the pipe racking over to and connecting with the high-tension control board.

Figure No. 4 is a front view of the high-tension control board mounted flush into the wall separating the generator room from the transformer vault. This switchboard is entirely dead front and provisions have been made in the wall for the two future panels to control the additional motor generator units. The first panel at the left controls the main high-tension oil switch for the entire plant. Panels 1, 2 and 3 are used to start the 435 H.P., 7,600-volt synchronous motors driving the motor generator sets. A branch of the high-tension service rises to the upper level of the transformer vault shown in Figure No. 5 and is tapped off to the various high-tension disconnect switches and fuses protecting the transformers whose secondaries supply 220-110 volts, three-phase current for the general house lighting and power.

Figure No. 5 shows the work under construction and gives an idea of the relative arrangement of upper and lower levels of transformer vault and also shows in detail the rear of the main high-tension control switchboard.

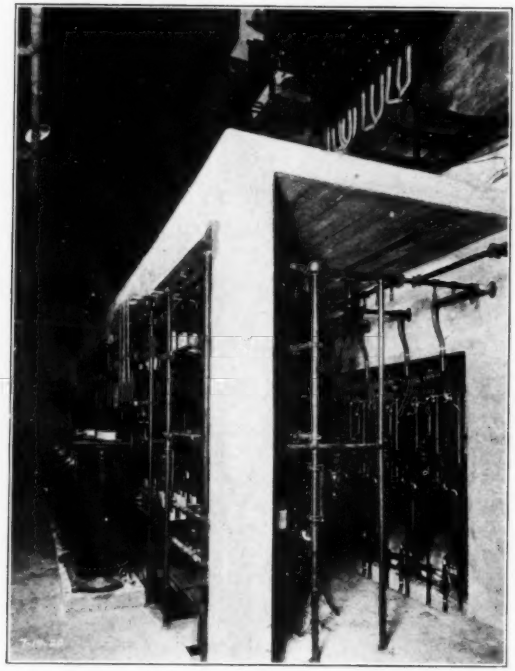


Figure 5—Perspective of upper and lower levels of high tension vaults during construction.

Figure No. 6 shows the arrangement of the lighting and power transformers on the upper level and it is to be noted that each trans-

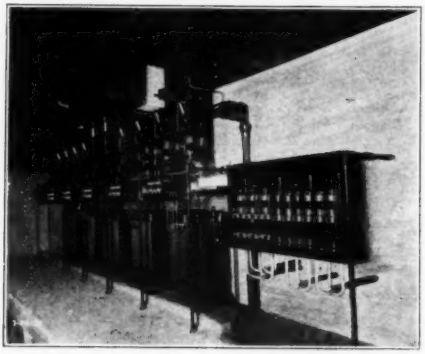


Figure 6—Transformer equipment for house lighting and power, upper level of high tension vault.

former is provided with not only primary disconnect switches which are connected to the high-tension bus bars but also with secondary disconnect switches which in turn are connected to the main low-tension bus bars running horizontally over and across the various transformers to the main low-tension service board shown to the right of the photograph. From this service board, the feeders run to the main low-tension switchboard in the generator room. The pipe racking and disconnect switches shown in this photograph were designed so that when a repair or replacement of any transformer is required, it is necessary for the operator merely to open the secondary disconnect switch and throw the primary disconnect switches into the lower jaws, thereby insuring the repair man that the transformer leads are of the same potential as the ground. The racking and secondary bus bar feeders are arranged so that a transformer can be removed by loosening a few of the connections and

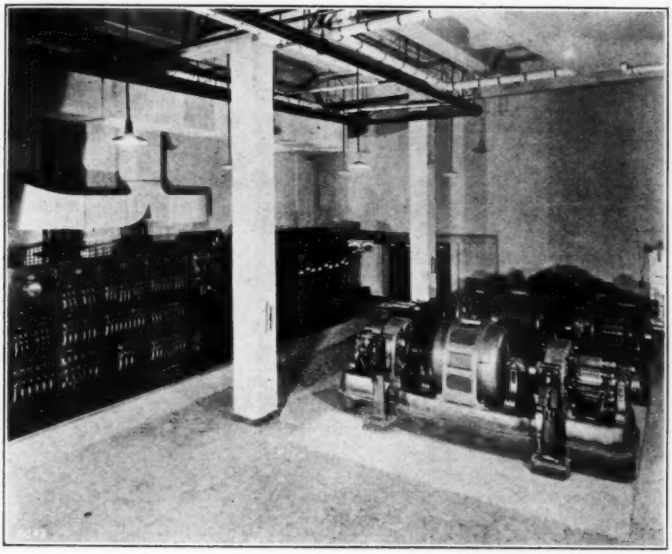


Figure 7—General view of generator room, showing main switchboard at left.

rolling the transformer out of its compartment without interfering with the operation or the arrangement of the rest of the equipment.

From the main low-tension service board shown in figure No. 6, light and power feeders are run to the main low-tension switchboard in the generator room shown in Figure No. 7. This switchboard is approximately 35 feet long and 8 feet high and is designed to control ultimately 10-150 K.W., 125-volt direct current generators operated in pairs. The direct current generator control panels are located at the right of the switchboard and three panels are equipped at the

present time for the control of the present three sets of generators. Blank panels have been provided for mounting future generator equipment. The studio circuit breaker sections are located in the center panels of the switchboard and are each equipped with 5,000-ampere, two-pole circuit breakers and 5,000-ampere, three-pole, knife switches with ample space for recording instruments. The left sections of the switchboard are used for feeder switches controlling the various house lighting and power feeders. All the various generator leads are brought to the main switchboard with the exception of the equalizer leads which connect to knife switch pedestals, two of which are installed with each motor generator set. The various outgoing feeders and the generator leads are all brought underground into the switchboard through a long trench. The usual method of dropping conduits down to the top of the switchboard from overhead is avoided. The generator sections of the switchboard, Fig. 7, are each equipped with safety stop devices and the circuit breakers are interlocked with the main oil switches, preventing the operator from throwing the generators on to the direct current bus bars unless the high-tension motor driving the generators is running. The motor generators are equipped with over speed devices which will trip out the main oil switches should the machines get out of step.

The generators are of standard General Electric 40° design, but the motors driving them were specially designed for the present 7,600-volt service with special taps for a change-over to 4,000-volt service which is contemplated in the near future.

The motors are of the synchronous type, rated at 435 H.P. and will operate with 25% overload for a period of two hours with very little rise in temperature. A feature which cannot be emphasized too strongly is that of intermittent overload capacity in equipment used in large studios. The compensators used for starting these synchronous motors also have a special "five minute" rating for starting duty which provides additional insurance against burning them out or over-heating under abnormal starting conditions. This feature is also important since these sets may at some time be started by an inexperienced operator and may require several attempts to start a machine and bring it up to synchronous speed so that it can be thrown on the line without causing a surge disturbance.

III. High Capacity Feeder System for Direct Current Studio Equipment.

On account of the large current requirements for the studio lighting equipment, a great deal of consideration was given the feeder system intended to supply the various studio switchboards. It was considered quite impracticable to install the feeders using the conventional insulated cables in conduits, since the cables required would have been of unusually large sizes and the conduits to protect them correspondingly large and cumbersome. The feeders to the various switchboards could have been run by doubling or trebling the number of cables per leg and with this arrangement, each switch-

board would have been provided with a separate feeder and the total load taken off any single switchboard would have been limited to the size of the individual feeder supplying it.

To avoid these conditions and to provide a feeder system of the utmost flexibility and one in which its capacity might be increased at some future time without extensive changes, a bare bus bar system was designed having sufficient capacity to take care of all the present requirements. This consists of a single bus bar feeder for each studio which passes virtually through all the switchboards. If necessary the entire plant capacity can be taken off a single switchboard without overloading the feeder. In addition to this feature, a minimum drop in voltage is obtained and the studio is utilizing 100% of the copper installed in the building all the time. With a separate feeder system (individual feeder to each switchboard), there may be times when as much as 90% of the copper is not in use. The bus bar feeder system is nothing more or less than an extension of the main switchboard in the generator room and as designed in this studio is equivalent to the power plant being placed up over the studio alongside of the various studio switchboards. There are many advantages accruing from a system of this kind, some of which may be briefly stated as follows:

a. The currents handled are relatively large compared to those that can be handled by insulated cables on account of the greater amount of radiating surface exposed to the air and the facility for keeping the copper at a lower temperature for much greater current densities.

b. Due to the low operating temperature of the bus bars as compared to cables, the actual power loss in the copper is less.

c. Due to the large amount of radiating surface, the overload capacity of a bus bar feeder is greater than that of any cable having an equivalent copper cross section.

d. Due to the absence of deterioration of insulation (porcelain is used for insulation), a bus bar installation is practically permanent. The life of a cable installation may be from five to ten years, depending upon the overload demands made on the system and is dependent entirely upon the detorioration of the cable insulation.

e. Bus bar systems offer easy facilities for increasing the capacity by simply adding laminations. Cable systems require the installation of new conduits if the present conduits are too small or else the withdrawal of present wires and the installation of heavier wires. Bus bar systems offer the advantage that they may be increased in capacity in one section of a plant with copper removed from other sections of the plant which may not be so heavily loaded. It is quite impossible to do this with cables.

f. Bus bar systems are easy to inspect and offer splendid facilities for making repairs. Cable system when needing repair, usually requires an entire new length of cable should even a small section of it become damaged.

g. So far as the actual insulation is concerned, bus bars are

better insulated than the ordinary interior rubber-covered cable for the reason that high-voltage porcelain is used throughout (in this particular installation the porcelain was tested at 6,600 volts whereas the actual operating voltage is 110), and the insulation resistance of a bus bar system as shown by actual test is many times greater than that of an insulated cable system using commercial grade of insulation. The bus bars in this particular installation are protected by wire grille mesh work with large air spaces between the grille work and copper work so that it is practically impossible even if the grille work is damaged to come in contact with the bus bars.

h. The cost of a high capacity bus bar system for large amounts of current usually, as in this case, is not much greater than that of a cable and conduit system having the same capacity, and affords all the additional advantages mentioned.

The outstanding feature of the design of this system is the fact that the institution can expand and the feeder system can also expand without any material changes to the present system and with very little additional cost. The feeder system installed in the upper studio is intended for an intermittent load of 10,000 amperes at 125 volts or 8,000 amperes continuously and in the lower studio an intermittent load of 8,000 amperes at 125 volts or 6,000 amperes continuously.

Figure No. 8 is a photograph of the bus bar feeder (before being enclosed with grille work) coming out of the generator room and rising up the studio wall. The insulated heel supports shown are designed to take the vertical thrust of the bus bar and to withstand the dead load as well as the strains due to expansion and contraction of the copper.

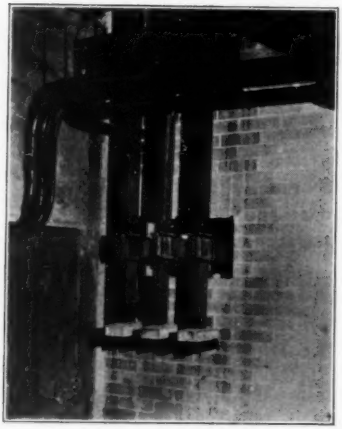


Figure 8—Bus bars coming from generator room and rising to footwalks.

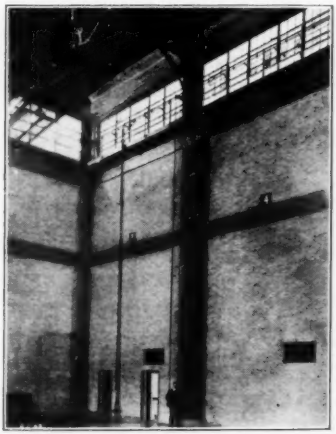


Figure 9—View showing entire vertical bus bar running up wall of upper studio.

The insulators used for supporting these bus bars are designed to each carry an ultimate stack of six 4″x ¼″ copper bars and the braces are installed approximately every six feet.

A characteristic of a bus bar system which must be taken into consideration is the phenomena of mechanical forces due to magnetic effects tending to thrust the bus bars apart under short circuit conditions. It was calculated that the horizontal thrust strain on short circuit for this particular system is approximately 409 pounds per foot with 8″ centers between opposite polarities. The wrought iron braces and insulators being placed every six feet, required insulators designed to withstand a short circuiting stress of 2,454 pounds per insulator. The insulators furnished for this installation were tested at 4,100 pounds cantilever stress. Another condition which had to be provided for, was that of expansion and contraction of the copper with varying temperatures based on the worst condition in the winter when the building might not be heated, to the highest temperature in the summertime. In order to provide for the expansion and contraction, the bus bars are so held in the insulators that they may slide through them without subjecting the porcelain of the insulators to any abnormal strains. The insulator bases are provided with slotted holes for expansion and it is intended that these also will assist in compensating for the expansion and contraction. Ordinarily in a system of this kind, special extra flexible "U"-shaped laminated expansion joints should be installed along the line of the bus bar which function very much the same as expansion bends do on a steam line. However, on account of the peculiar conditions in this studio, the system is arranged without these bends.

Another feature in the design of the bus bar system was the question as to whether the bus bars which come in lengths of from 10 to 12 feet should be butted or lapped between lengths and it was decided that all vertical runs should be butted so as to prevent a bar from falling out of the insulator and sliding past a lower bar in the event of any undue expansion. Where the joints were butted, copper splicing plates were used on each side of each lamination to carry current from one length of bus bar into the other. These splicing plates and bus bars are all "ground in" and clamped together solidly to obtain minimum surface contact resistance. In the horizontal bus bar runs, the ends of the various lengths of bar were also "ground in," but lapped instead of butted and clamped together solidly to obtain minimum contact resistance. In this type of construction, the copper splicing plates were unnecessary.

Figure No. 9 is a photograph of the bus bar system for feeding the upper studio run up the surface of the upper studio wall to the roof space above.

Figure No. 10 is a photograph of the feeder after the switchboards had been set in place and after the bus bars had been enclosed with wire grille. This bus bar feeder passes through five switchboards similar to the one which is in the foreground of the photograph and there are five other similar switchboards in the roof space

over the upper studio, which are sub-fed from those just mentioned.

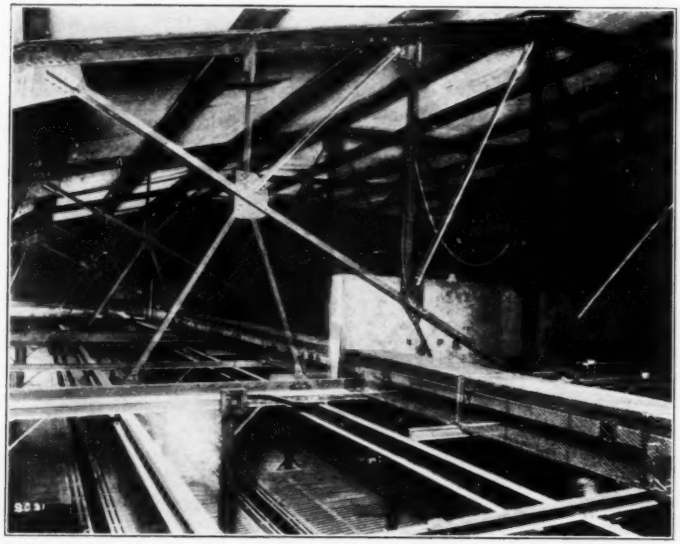


Figure 10—Main bus bar feeder running thorugh roof space and overhead switchboards after completion.

IV. Studio Switchboards and Plugging Box Equipment.

Over the upper studio are ten remote control studio switchboards installed similar to the one shown in Figure No. 11. In the lower studio there will ultimately be approximately nine of these. This photograph shows the switchboard mounted in a steel cabinet braced to a roof truss and consisting of the remote control section used for controlling the floor, lamps and top lights from a control box placed on the studio floor and a distribution section which supplies the various high capacity pockets for use with spotlights and high intensity arcs. The spotlights and arcs are usually hand-controlled at the lamp and it has, therefore, been considered inadvisable to put these on the remote control section. The advantages of the remote control system designed for this studio over that of the old type conventional switchboard systems, are many.

a. By its use, valuable floor space is not occupied by cumbersome switchboards.

b. By installing the switchboards overhead, the various stage cables may be dropped from overhead to the exact point at which they are required on the studio floor instead of having them lie across the floor interfering with stages in operation and with the moving about of scenery, floor lamps, etc. This interference is not only annoying but actually ruins the insulation on the cables.

c. The switchboards being placed out of the way, it is impossible for anybody to touch the live parts or to be near any arcs of the switches when making and breaking circuits.

d. By its use, several stages may be worked at one time in the same studio without confusion, since the director need not shout to the operator at the switchboard controlling his stage, thereby disturbing his own and the other companies which may be working, or cause delays due to misunderstandings on the part of the switchboard operator.

e. The facility for the director or camera man to operate or directly supervise at close range the lighting on his own stage without calling for an electrician and without disturbing or distracting the players' attention by shouting orders to other people.

f. The switchboard operator need not remain at the switchboard

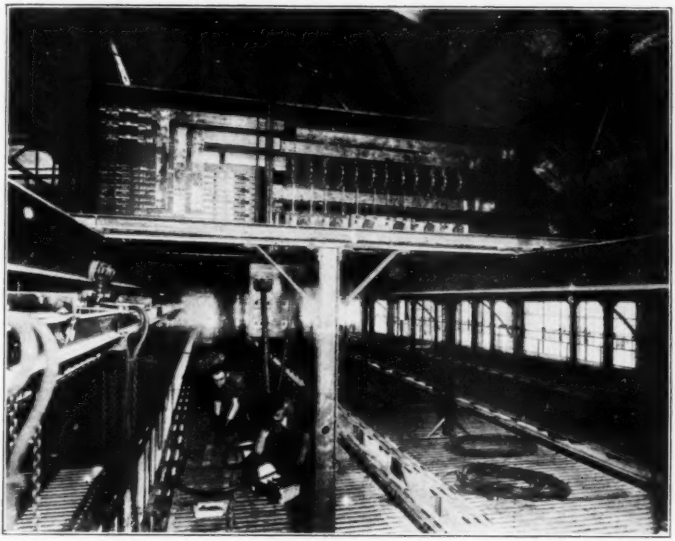


Figure 11—View showing 6-gang plugging box and method of plugging in on footwalks over studio.

waiting for a cue to switch "on" and "off" lights. Almost any kind of special effect lighting can be controlled from the stage in combinations of one, two, three or four groups. It is also possible to arrange a switch on the "props" itself which the actor can operate so as to obtain absolute synchronism of the lights with the action of the play, eliminating thereby the time interval or lag usually noticed on the screen when the actor is supposed to turn "on" or "off" the lights in the room which he is entering or leaving.

g. To obtain lightning effects with the old type of switchboard, it was necessary for the switchboard operator to pull open

and close one of the large master knife switches which not only caused considerable arcing of the switch and distracted the actor's attention, but also burned away the switch parts so that replacements or repairs were often necessary after such a scene.

With the remote control system, the director or camera man has at his command a number of keys which control the various lights or groups of lights as desired. With these operating keys, it is possible to obtain effects identical to those produced on the theatrical stage. The lights can be instantly turned off as soon as the scene is completed or while the scene is held for further instructions or rehearsal, thereby effecting a considerable saving in current consumption and the trimming of arc lamps.

Each of the remote control switchboards in both upper and lower studios are equipped with six sets of Lasky type contactors manufactured by the Sundh Electric Company. These contactors

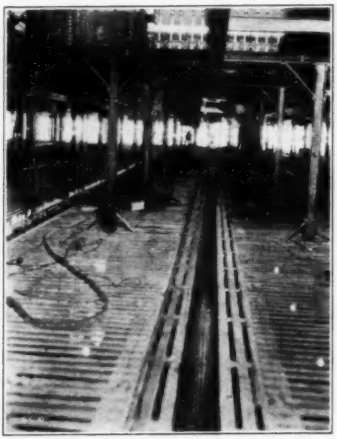


Figure 12 — Method showing manner of shifting top lights on overhead monorails. Also note surplus cable not required on studio floor.

were designed to withstand a continuous overload of 100% and are provided with special magnetic blowouts so as to extinguish heavy inductive arcs on breaking the circuit.

Referring to Figure No. 11, the bus bar feeder is shown passing through the lower right-hand portion of the switchboard and the switchboard bus bars tapped directly into this feeder. The fuses shown over the contactors protect the various contactor circuits and when repairs or replacements are necessary on any single contactor, its fuses may be removed without interfering with the rest of the equipment on that particular switchboard. From the knife switch section of the switchboard, branch feeders are run to the various spotlight and arc pockets located over the footwalks of the upper

studio. From each group of switchboard contactors in upper studio feeders are run to a plugging box placed directly underneath the switchboards as shown in Figure No. 11. Each plugging box has a capacity for six three-wire circuits arranged for connecting to six-gang portable spider boxes placed on the footwalk for the top lights or on the studio floor below for the floor lamps, and each contactor unit thereby controls all the lights connected to a six-gang spider box.

The overhead footwalks as shown in Figure No. 12 also hold the surplus stage cable and are used for facilitating the moving about of the overhead lighting equipment. A system of monorails supporting the overhead lamp equipment runs lengthwise through the entire studio on approximately seven-foot centers. These monorails hold rolling carriages and chain blocks dropping through 6″ slots in the

Figure 13—View of part of upper studio in operation.

footwalks from which the Cooper-Hewitt and other overhead lights are hung. This photograph shows one of the men pushing the rolling carriage along the monorail.

Figure No. 13 is a photograph of part of the upper studio showing stages set up with top lights, etc. The scene docks are shown to the right. In the foreground of this photograph is a cable dropping down from overhead to a portable Monitor station on the floor which is used by the camera man or director. The photograph does not show any stage set up at this particular point, but these cables may be dropped to any part of the floor as desired.

The Monitor studio remote control station as shown in Figure No. 14, specially developed for the Famous Players-Lasky Corporation, consists of a series of "break-back" switches which are thrown from one side to the other or held in a neutral center position similar to the listening keys on a telephone switchboard. These stations are ruggedly made and designed to stand all the abuse which equipment of this kind is subjected to in a studio. The pin plug connector coupling at the top permits removing the station from the portable cable so that it is unnecessary to hoist the heavy box out of the way. The left vertical key of this device is a Master which controls the left positions of all of four of the sectional keys. The left positions of the remaining two sectional keys are connected directly to the line and are not controlled by the Master. The upper right vertical key is also a master which controls the right positions of all of the sectional keys. By means of the Master keys, two

Figure 14—Photograph Showing Portability of Monitor Remote Control Station

large groups of lamps can be controlled in one operation and by means of the lower left positions of the two lower keys, a third group of lamps can be controlled independent of the Masters. One of the section keys can throw "on" or "off" all the lamps connected to a single spider box usually consisting of six. The operation of one Master can throw "on" or "off" all the lamps connected to six spider boxes usually consisting of about 36 lamps. As previously stated in the design of the contactors, 100% overload capacity was provided for, and the contactors were designed not only to

carry this overload without perceptible heating but also to break the circuit without dangerous arcing or deterioration of the contact surfaces. The Monitor remote control stations are also arranged with auxiliary pin plugs in the lower part, not shown in the photograph, whereby the master keys on the control station can control all the lamps corresponding to two or more other control stations with a single operation. This feature is accomplished by connecting together the various control stations by means of light portable No. 14 gauge conductors in train line fashion and this arrangement will permit the various switchboards to function in a manner similar to the Master Controller on an electric railway train consisting of several cars. The principles of the remote control system are by no means new. For the past ten years because of the safety, simplicity, saving in time, minimizing of maintenance expense and the absence of delays due to breakdowns, it has been developed and applied to the largest industrial plants in the world where hundreds and hundreds of horsepower in motors are remotely controlled.

For the lower studio, the same type of station is being constructed with the exception that there will be three Master keys instead of two, the left positions on all of the sectional keys being controlled by two Masters instead of one.

Figure No. 14 gives an idea of the compactness and portability of this control station and one must marvel that this little box functions as completely if not more so than the old-time conventional switchboard that usually occupied from 40 to 60 square feet of valuable studio floor space.

Disadvantages.

The various advantages of the overhead system as installed in this studio are many but there are a few disadvantages of which mention might be made at this time.

a. For studios having considerable height, such as this one, the cables dropping down from the footwalks are very heavy and difficult to handle unless a winding reel or special counterweight system is employed. The result is that the cables are not always lifted up and dropped to the most advantageous locations, but are partly laid on the floor.

b. Another disadvantage is the hazard connected with men working up overhead and dropping plugs, pliers or other tools through the slots in the footwalk down to the stage floor. Of course, this latter condition also exists in studios where all the connections are made up on the floor and where the men hang scenery and top lights while working on scaffolds and ladders.

An advantage of the footwalks, forming part of the overhead system, which offsets all of the disadvantages and which appeals to every studio manager, is the facility for hanging scenery effects and lights from some sort of overhead fastenings. An ideal studio would be one having its ceiling constructed of a horizontal net work of steel ropes, the strands of which are capable of supporting

approximately 1,000 pounds every five feet. It is a known fact that the location of the hangings for overhead equipment including props, is always uncertain. The overhead footwalks and structural arrangement of this studio is equivalent to having the ceiling studded with eye bolts or the improvised horizontal network of steel rope. The overhead footwalks are very valuable as runways for the men to work on, but just as much so for the property men to hang their scenery and special lighting equipment.

V. Telephone Systems.

This studio is equipped with two distinct telephone systems, one consisting of a 20-trunk line, New York Telephone Company's PBX switchboard with its operators and approximately 150 extension instruments throughout the studio. The other system consists of a 200-line automatic switchboard and 100 extension instruments located throughout the studio and Laboratory Buildings. The automatic telephone system as is generally known, does not require any operators for making connections between extensions and has unlimited capacity so far as concerns the number of extension instruments which it will accommodate. The automatic switchboard equipment installed has an ultimate capacity of 200 lines, and was furnished and designed by the Automatic Electric Company and is similar in all respects to their PAX system now operating in several of the smaller cities throughout the country. No other automatic intercommunicating system available at the present time can accommodate as many extension phones as are installed in this plant.

VI. Fire Alarm System.

The building is completely protected by a combination watch and fire alarm system, stations of which are used ordinarily for transmitting signals by the watchman while making his rounds. These signals go to a central office outside of the plant, supervised by the local telegraph company, and logs are kept of the rounds made by the watchman which are submitted to the owners at the end of each week. In other words, the watchman is supervised and unless he sends in his signals regularly and periodically, the supervisor goes to the building to determine the cause for the irregularity. In case of fire, the same station is used, but a different type of signal is registered in the central office by means of which the supervisor knows it is a fire signal. He then communicates directly with fire headquarters, obviating the necessity of going to a fire alarm box on the street to send in the alarm.

VII. Miscellaneous Signal Systems.

On account of the large area covered by the studio and the difficulty in summoning principals who may be on the stage floor, to the telephone or otherwise, a special electric silent call system using an electric numerical monogram signal has been devised,

similar in appearance to the common carriage call used by theatres. The telephone operator will be provided with a U. S. E. M. selector type keyboard, which is arranged to light up monogram signalling panels located under the footwalks in the upper studio and at the same time giving a single stroke on a gong, attracting attention to the illuminated signal. By means of this special selector, numbers ranging from 1 to 999 may be set up without the use of the customary perforated cards and other complicated apparatus used with carriage call systems. An outstanding feature of this silent call system is the fact that one does not have to stop work to count the number of strokes on a gong in order to interpret the signal. It is merely necessary to glance up at the electric monogram to see whether or not the signal concerns one. The interference with the work on the stage is but momentary as compared to the gong and horn system used in many plants. The wiring for this system is quite simple and consists of 26 No. 14 wires and two No. 10 wires run as a single cable from the selector to the electric monograms. The current supplied is obtained from the house lighting circuits.

Another system of special signalling devices was installed in some of the private offices of the executives, operated by a foot push and lighting a lamp over the secretary's desk. By means of this signal, a principal can summon his secretary without detection or suspicion on the part of the visitor and the secretary can then either usher the visitor out or find a ready excuse for calling the executive away from his desk and in that manner dispense with the presence of an undesirable visitor in a polite and expedient manner.

VIII. Laboratory.

The Laboratory Building shown in Figure No. 15, receives its electric current supply over three different services from the main switchboard in the studio generator-room across the street. The Laboratory Building is supplied with alternating current, 220-volt, three-phase for the various motors and 220/110-volt alternating current for the lighting. There is also a direct current emergency feeder connected to the direct current bus bars on the main switchboard in the generator room which may be used for the printing lamps or the Cooper-Hewitt equipment on the cartoon and titling cameras in the Laboratory Building.

A 5½ K.W. motor generator set has been installed in the Laboratory Building to supply direct current, 118 volts, to the printing lamps on the film printing machines and to the Cooper-Hewitt lamps on the cartoon cameras. In order to keep this voltage at a constant value for printing, an automatic voltage regulator is employed, the details of which are familiar to most of us. The Cartoon Department in the Laboratory is rather unique. Each cartoon camera is operated by a small motor, which is started and stopped by means of a foot treadle. The sketching frame on the table directly beneath the camera is illuminated by Cooper-Hewitt "U" tubes on either side.

The Laboratory Building is equipped with a large number of connections for supplying alternating current to monoplane lamps and projection machines. The various circuits feeding the printing and perforating machines are run to distributing panels located outside of the actual work-rooms. The advantage of this arrangement is obvious when replacements of blown fuses are to be made and when one considers how difficult it is to do this in a dark room.

The Air Conditioning Plant in the Laboratory Building requires considerable power for driving the various refrigerating and pump machinery, all of which is supplied from the transformers installed in the studio building. There is also to be installed a breakdown emergency secondary service, which will supply a limited amount of current for both light and power into the studio and laboratory

Figure 15—Famous Players-Lasky Laboratory Building.

buildings in the event of a breakdown in the high tension supply of the main building.

A special feature installed in the Developing Rooms is the application of a small transformer for supplying low voltage to automobile type lamps which are protected in a transparent ruby waterproof casing and which are submerged into the tinting solutions to ascertain the color density of the solution. These are also used by the developers as hand lamps between the layers of film on the frames in preference to the regular ruby wall boxes for examining the density of the film. With this low voltage arrangement, a lamp of small candlepower can be used and the entire outfit is in such

flat and compact form that it can be contained in the palm of the hand.

The exhaust system in the Perforating Room is worthy of special mention. This system is made up entirely of threaded pipe fittings and no sheet metal ducts are used. This eliminates entirely air leaks and a great portion of the noise usually caused by the exhausting air travelling at high velocity.

In the Drying Room, the ten revolving drying drums are driven by two jack shafts, each jack shaft connected by a silent chain drive to a motor. Although each drum is not provided with individual drive, it is provided with a friction clutch so that it can be stopped without necessitating the stopping of the other drums, the jack shaft or the motor.

The projection machines used for inspecting film are each equipped with a foot treadle which operates a friction clutch so that the motor may continue to run but the film stopped, quickly and suddenly at any point at all for cutting, examining or notching.

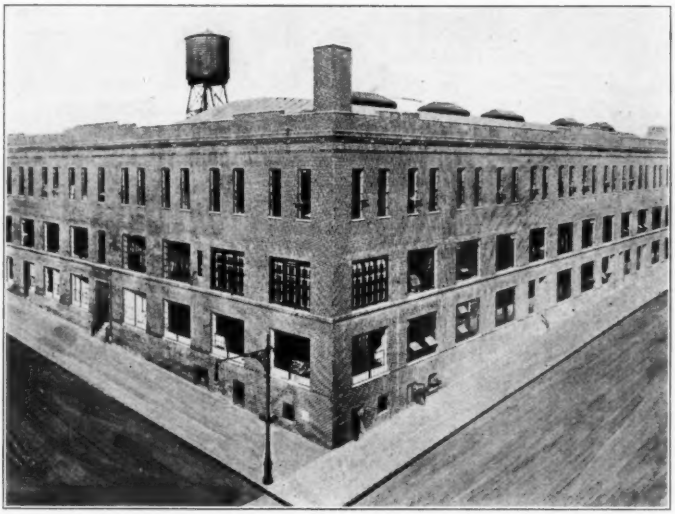


Figure 16—Studio and Laboratory Building of the Fox Film Corporation, New York City.

FOX FILM CORPORATION STUDIO AND LABORATORY

I. General Description of Building.

The Fox Studios, Laboratories and Executive Offices are all housed under one roof in a four-story brick structure occupying the entire block from 55th to 56th Streets and 10th Avenue and running approximately 300 feet east on both 55th and 56th Streets, to the floor lamps, but the arrangement of the various pockets and

which is the largest single building in New York City devoted to the industry. The photograph shown in Figure No. 16 is a view of the building from the 10th Avenue side.

The lower floor is devoted entirely to the Film Laboratory and is operated as an entirely separate and distinct branch of the corporation. This Laboratory is one of the finest in the world and one is impressed upon first entering it by the great amount of white tile used throughout, for the ceilings, walls and floors. This part of the institution is absolutely dustless and practically fire-resisting.

The executive offices, scenario rooms, projection rooms, dressing rooms, restaurant, etc., take up the entire second floor.

On the third floor are the two studios, covering approximately 35,000 square feet of floor area, one studio measuring 275 feet in length by 100 feet in width by 22 feet in height, and a smaller studio measuring 105 feet in length, 96 feet in width and of the same height as the larger studio.

II. Source of Current Supply.

Electrically, the building is divided into three sections, Laboratory, Administration and Studio.

There are four different sources of central station supply, one alternating current 220/110-volt two-phase service for the Laboratory lighting and power, and three direct current 220/110-volt services for the Studio and other lighting. The combined capacity of the direct current services supplying the studio switchboards totals 13,000 amperes at 120 volts. The various services brought into the building are independent of each other so that the failure of one will ordinarily not affect the remaining services thereby enabling the studio to continue its work without interruption due to this cause. The alternating current in addition to supplying the motors on the Laboratory equipment also supplies the motors in the carpenter and machine shops, refrigerating, heating and air conditioning plants and ventilating system. The air conditioning plant alone consumes approximately 300 H.P. and is used to regulate the temperature and humidity for the developing and printing machines and for general conditioning of the laboratory air.

III. Feeder System for Studio Switchboards.

The Studio is equipped with six remote control switchboards quite different from those installed in the Famous Players-Lasky plant. These six switchboards are supplied by three main feeders arranged in a manner so that all the copper of these feeders is always in use and when the feeders are not carrying full load current the drop in voltage is practically negligible due to the fact that all the copper installed is in service all the time. This arrangement approaches as nearly as possible that of the bus bar system described in this paper.

IV. Studio Switchboards and Plugging Box Equipment.

The Studio is equipped with six combination manual and remote control switchboards, each measuring approximately 11 feet in length by 10 feet in height, enclosed and protected on all sides and top by wire grille work. The manual sections of the switchboards consist of double-throw knife-switches for feeding the various lines running to pockets on the side walls and overhead, and are supplied by a double bus bar system. Each of the double set of bus bars is controlled by master knife-switches of high capacity used for manual control of "effect" lighting. In addition to these master knife switches, each switchboard is equipped with from six to eight heavy-duty type remote control magnetic switches which are operated from the stage by the director or camera man in a similar manner to the remote control system described elsewhere in this paper. These magnetic switches are of high capacity in order to handle the heavy currents required by the special control and are each equipped with a vacuum dash pot device which eliminates practically all the noise occasioned by the closing and opening of the heavy contacts. It is obvious that this noise would be very objectionable on the stage floor and might interfere with the players and directors. These vacuum dash pots in addition to eliminating the noise, reduce the wear and tear on the remote control switches. The application of remote control switches to these special conditions and the special dash pots with which they are equipped, was under the direction and suggestions of Mr. Walter J. Quinlan, the electrical engineer for the Fox Film Corporation, who is also a member of our Society. In order to obtain the combination manual and remote control in this studio, it was necessary to sectionalize the main bus bars on the various switchboards and intercept each of these sections with a remote control switch of proper capacity.

The wiring equipment consists of heavy feeders to three-wire wall pockets located on the walls around the studio, each controlled by a double-throw knife-switch on its corresponding switchboard. Branch circuits of lower capacity run to the various overhead plugs for direct connection to the top lights without the use of spider boxes.

The system designed for the Fox Studios, while more expensive than any system ever installed in any studio in the world, is considerably more flexible than any other system.

Not only can the lights be remote controlled from the stages out on the studio floor for special effects, but when any change is necessary in the combination or number of lights, it is unnecessary to interfere with the plugging equipment or with the cable connections on the stage floor. To make such a change, it is merely necessary for the electrician to go to the corresponding stage switchboard and throw the various knife-switches connected to certain pockets on to the proper bus bar and proper remote control switch. The advantage of this feature is apparent since there are no overhead footwalks necessary in this studio and changes can be quickly made,

without interference to the sets on the floor and without one stage interfering with the other. The switchboards are also arranged so that several stages can be operated from the same board independent of each other without interference.

The top lights are hung from an overhead track system of the Louden make, fastened to wooden roof trusses and cross beams with a very complete system of switching frogs which enables the convenient transferring of top lights from one stage to the other.

The overhead rail system is of light construction and is "T" section in shape and weighs slightly over one pound per foot. These tracks are fastened with special adjustable suspension hangers every few feet. Although the track system is very light in weight, it functions more satisfactorily than any overhead track system yet designed for studios. The carriages which roll on these tracks are also light weight but are highly efficient on account of their ingenious construction and roller bearings. The top lights are hung from these carriages by means of small chain blocks used for raising and lowering as desired.

The total plugging equipment in this studio could supply 25,000 amperes at 120 volts if all were used at one time but this total capacity is unnecessary in the feeders since it will never be required simultaneously.

The control stations for operating the remote control switches consist of portable cabinets containing standard push switches arranged in gangs and function in a similar manner to the Monitor remote control station described in this paper. In addition to accomplishing the various features already mentioned in connection with the remote control station, each one of the stations used in this studio is equipped with an electrical lockout device which prevents operating certain buttons on the station which may be in use on another station by some other stage. This arrangement was necessary since an entire switchboard can be controlled from any single station or from a number of stations and provisions had to be made so that one station using only part of the switchboard could not interfere with the other.

V. Advantages and Disadvantages.

The various advantages of the overhead system have been previously described, but these advantages would not apply to this particular studio.

Since the height of the studio is limited and since the clear space from floor to roof trusses is utilized by the scenery, an overhead footwalk system was quite impracticable. In addition to this, the overhead top lights can be readily moved about on the studio floor by means of long poles so that the footwalks are unnecessary for this purpose. It is true that the cables are strewn on the floor from the various wall pockets to the spider boxes supplying current

switchboards is such that in very rare cases do the cables of one stage interfere with those of the other.

There is the disadvantage, of course, of the abuse to which the cables are subjected, but the easy means of making up connections and plugging-in without going up overhead seems to offset these disadvantages.

In regard to the fastening of scenery and props from overhead structural members, this is provided for by the timbers which support the overhead track and cross timbers used as stiffeners between roof trusses.

In making comparisons of an overhead equipment with that as installed in this studio, it has been the consensus of opinion that the system as designed here has worked out much more efficiently than an entirely overhead system on account of the peculiar conditions of the building.

In addition to the studio lighting equipment, a very complete system of work lights has been installed with controlling switches placed on each of the various studio switchboards.

A special system of watchman's lights has also been installed on the side walls around the studio, approximately 20 feet above the floor on pilot control, so that the watchman in making his rounds pushes the switch at one end of the studio aisle space and extinguishes that row of lights at the other end, lighting up the next row at the same time, and so on. With the installation of these lights, it is unnecessary to burn the work lights all night, thereby effecting a considerable saving in current consumption.

VI. Telephone System.

This Studio is equipped with two distinct telephone systems, one consisting of a PBX exchange switchboard connected with the New York Telephone Company's lines and approximately 200 extension instruments throughout the building.

The other system consists of an intercommunicating Dictograph system which provides intercommunication only between departments that have business with each other. For instance, some instruments can communicate with 25 different points, whereas others can talk to only three, or four or in some cases only one. This prevents waste of time in private conversation and keeps the lines always open for necessary conversations.

To accomplish all the features of an intercommunicating system, a very intricate net work of cross connections was installed and some of the executives' instruments are equipped with a special device for supervising conversations between various departments, cutting in to the system and obtaining right-of-way in preference to conversation which may be going on, and many other special signalling facilities.

VII. Fire Alarm System.

The building is completely protected by a combination watch and fire-alarm system, stations of which are used ordinarily for transmitting signals by the watchman while making his rounds. These signals go to a central office outside of the plant, supervised by the local telegraph company and records are kept of these signals which are submitted to the owners periodically. This part of the system is identical with that of the Famous Players-Lasky Corporation's system. However, the fire alarm part of the system is somewhat different from any which have heretofore been installed in a building of this type. It is generally known that a fire in a film building, no matter how small, causes considerable excitement and panic amongst the employees and very often in film laboratories, the actual damage by a small fire is nil compared to damages caused by turning on the "white" lights in the various developing and printing rooms or by the developers running out of their rooms and leaving the film in the tanks. This condition has been ingeniously provided against by Mr. Quinlan in designing the fire alarm system, so that the first alarm sounded from any box is received only by the chief mechanic in charge of the laboratory. He then investigates the fire and if it is a serious one, goes to the nearest station and sends in either an alarm summoning the people in the laboratory only, or an alarm summoning the people in the entire building.

The fire alarm in addition to recording at the telegraph company's headquarters, also sounds gongs distributed throughout the building. This system as applied to other industries is known as the dual operation system, but no dual system at the present time functions as completely and efficiently as this one.

VIII. Laboratory.

The Laboratory Department, as mentioned before, is considered one of the most complete in the country and is equipped with all the up-to-date devices known to the art.

For the printing lamps, special motor generator sets are installed and arrangements have been made so that when special night work is necessary on only one or two printing machines, a smaller motor generator set is run in preference to a larger one for maximum efficiency.

The projection rooms in the Laboratory, contain, without doubt, the largest amount of equipment of any projection department found elsewhere and are equipped with both alternating and direct current feeders so that either arc lights or monoplane lamps may be used. In addition to the laboratory projection rooms, a private projection room has been fitted up for Mr. Fox which contains practically every device used by the projectionist in a large theatre. A system of intercommunicating, loud speaking telephones is installed between the projectionist and the projection room for private conversation and discussion between the projectionist and Mr. Fox while the picture is being reviewed on the screen.

In conclusion may be stated that the advent of the mammoth studio into the motion picture industry for quantity production and maximum efficiency, when compared to the smaller studios of the past, will present many more interesting engineering problems which will be developed in studios of the future and will require the services of the engineer rather than those of the non-technical studio personnel of the past.

Acknowledgment and thanks is tendered at this time to the various principals in the Famous Players-Lasky and Fox Film Corporations and also to the various manufacturers, many of whom are represented in our Society, who have given their time and the benefit of their experience to the author in the preparation, design and installation of the electrical equipment in these two incomparable projects.

Portable Power Plants for Motion Picture Studios

By H. F. O'Brien

Synopsis

SO many different elements of design enter into the construction of the portable power plants used for studios that it would be impossible to attempt to bring all of their numerous advantages before you in a short paper. It is the author's hope that by bringing before you the most important improvements in this branch of Motion Picture Engineering, you would have a better understanding of the problems involved and should any member contemplate the construction of such an equipment he could at least derive some benefit by learning of the experiences of those who pioneered in this particular branch of the Motion Picture Industry.

Outline

1. Introduction.
2. Two kinds of portable plants—Gasoline Engine and Electric.
3. Discussion of engine-driven equipments.
   (a) Principal requirements.
      1. Portability.
      2. Continuity of service.
   (b) Results obtained from first equipments.
   (c) Comparison of horse-power rating.
4. Some features of design of equipments now under course of construction.
   (a) Using two generators.
   (b) Cooling systems.
   (c) Self-starters.
   (d) Voltage and speed regulation.
   (e) Carburetors.
   (f) Methods of mounting.
   (g) Switchboard equipment.
5. Discussion of Portable Electric Power Plants.
   (a) Three-Unit Induction Motor Generator Set generally used.
   (b) A.C. Switchboard and Metering Equipment.
   (c) D.C. Switchboard.
   (d) Electric equipments generally mounted on trailers.
6. Conclusion.

When the production of motion pictures was an infant industry, the scenes were almost entirely taken in natural sunlight. Because of the fact that Southern California is blessed with an abundance of sunlight several of the producing companies located there. It

was not long before conditions changed materially. More and more productions were made in enclosed stages and more and more intense artificial illumination was employed until at the present time nearly all large motion picture productions are made in enclosed stages, and more attention is being given to the proper illumination of exteriors and night scenes.

This improvement in the illumination of exteriors and night scenes presented many obstacles that had to be overcome, but the engineers and electrical departments are in the habit of solving the many and complex problems that arise in their everyday routine, and the problem of illuminating night scenes and locations has been quite successfully solved by using a portable electric generating plant of sufficient capacity to properly illuminate the setting.

This idea originated in the Western Studios where Mr. Harry Brown, electrical engineer for the Universal Film Man. Corp., constructed in 1915 a portable engine-driven plant of about 50-kilowatt capacity. At the present time every large western studio has one or more of these portable plants which they find indispensable. Inasmuch as nearly all of Southern California is covered with a network of high-tension electric power lines the studios have mounted motor generator sets on trucks or trailers so that they may be easily transported to "locations" where electric power is available.

Since the portable engine-driven outfits were used first and since they enjoy more general use on location work, we shall consider them first.

It is obvious to anyone that any portable power plant must meet the two principal requirements of portability and continuity of service. Those of experience will realize that these two apparently simple requirements present some perplexing problems to solve. It is not so difficult to design an outfit that may be comparatively light in weight and easily transported but generally the disappointing feature of such an outfit is that it will not give continuity of service under the severe conditions imposed by the application. The reverse is also true; i. e., that a heavy outfit with a good reliable gasoline engine could be constructed but it might prove very unwieldy and difficult to transport to the summit of some mountain where such outfits are often used.

The most common error in the earlier equipments was that the engine proved too small. Although some of these engines were rated as high as 200-H.P. by the manufacturers, actual results showed this rating to be excessive.

The most successful equipments now in operation have profited by the sad experiences of those who built the earlier equipments and have equipped their outfits with sufficiently large engines to insure satisfactory operation when the generator is fully loaded. It is interesting to note that a generator normally rated at 35 kilowatts will stand about all the load that the average gasoline engine rated at 150-H.P. can pull. If the engine was rated on a basis of actual horsepower over a 24-hour period, as the generator is, it would, of course, require only approximately 51 H.P. to deliver 35 kilowatts.

Past experience has demonstrated to the large western studios that it is almost useless to have a portable gasoline electric equipment unless it can be depended upon at all times. There are under construction at present in Los Angeles, about six of these equipments on which the studios are sparing no expense in their efforts to have them entirely successful.

Five of these outfits are being equipped with the famous Liberty engine used for aeroplanes. Slight alterations have been made in these engines; for example, the weight of the pistons has been increased, self-starters have been added, etc.

The author in a previous paper explained the advantages of the three unit motor generator sets which he recommended for studio application. It is gratifying to note that several of the studio elec-

Portable Gasoline Electric Equipment of Thos. H. Ince Studios, Culver City, Calif.
180 P. Seagrave Engine, 75 K.W. Westinghouse Generator

tricians have from past experience found this scheme of using two 115-volt generators connected in series, so satisfactory for their 3-wire, 115-230 volt systems that they are carrying out this idea in their portable equipments.

In the equipments now being constructed these Liberty Engines having a normal rating of 434 H.P., at 1650 R.P.M., will be direct connected by means of flexible coupling to 2-50 K.W. generators built into one frame and tandem connected on a single shaft. These generators are designed to carry heavy overloads for short periods and should prove well adapted for this service. The normal speed of these outfits will be 1100 R.P.M., at which speed the engine has a rating of approximately 320 H.P. The weight of the Liberty engine store is only 903 lbs.

There is a considerable amount of accessory equipment supplied on these portable sets and if one hopes to obtain successful results

from the completed unit he should give considerable care to the selection of these accessories. Probably the most important of these is the cooling system. It is necessary to use a very large radiator of the best design and provide a forced draft for it, as this outfit is stationary when in use and the radiation due to natural air circulation would be insufficient. The Metro Pictures Corporation is building one of these outfits and will have the blower fan driven by a series motor so that the operator in charge can vary the speed of the fan over a considerable range to keep the circulating water at the proper temperature as indicated by a thermometer.

It is very convenient, of course, to have some means of starting these large engines, other than by hand cranking. This is generally done by an electric starter as on an automobile although the Winton Engine Works supply a very satisfactory air starter which, of course, eliminates the necessity of transporting and charging storage batteries.

Large tanks should be provided for carrying ample quantities of water, gasoline, and lubricating oil, and these should be placed out of the way and piped so that the various liquids can be used where desired without requiring any handling.

Close voltage regulation is just as much desired on these portable equipments as it is on the motor generator sets in the Studio Substation, but it is somewhat more difficult to obtain. Some engine manufacturers supply a very good mechanical governor which actuates the throttle valve and will keep the speed of the engine constant within a range of about 5%. If this result can be secured it would, generally speaking, be satisfactory, but the author has seen some regulators designed by the studio electricians where a solenoid coil actuated by the generator voltage operated the throttle valve, giving excellent results. The first Liberty outfit to be completed is equipped with a governor built on the dynamometer principle and will regulate within 2%.

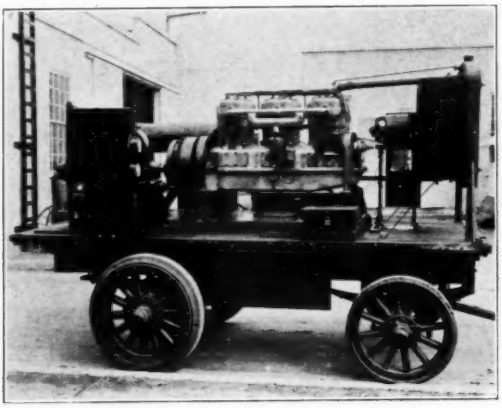
At least one of the studios seem to consider this matter of voltage regulation so important that they are also equipping the generator with an automatic voltage regulator which regulates the field current so as to produce very close voltage regulation over wide ranges of load.

One of the most important items to consider is the carburetor, which to be satisfactory on this application, must have the following characteristics:

1. It must accelerate quickly.
2. It must not choke or load up.
3. It must not be sensitive to changes in temperature, or altitude.
4. It should not have many delicate adjustments.
5. It should not be subject to changes in adjustment, caused by the vibration of the engine.

Those having had experience with carburetors will realize that while there are several carburetors of good reputation on the market there are very few that will meet all of the above requirements. There is at least one such carburetor manufactured in Los Angles, which, when properly adjusted on the initial test requires no further adjustments for altitude or temperature and gives excellent carburetion without the use of any needle valves or spray nozzles, a feature which makes it very successful on these portable power-plants.

There is room for some argument as to whether these gasoline engine driven sets should be mounted on a trailer or on a truck, but, generally speaking, these outfits should be designed so that they can be used in out-of-the-way locations where it is impossible to obtain any other power. Experience has shown that it is worth while to purchase a first class truck with its own motive power and a multi-



Portable Gasoline Electric Equipment of Goldyn Pictures Corp., Culver City, Calif.
6 cyl., 90 P. Wisconsin engine, 35 K.W. Generator.

speed transmission that will give a large gear reduction so that mountain roads can be negotiated without difficulty. Some studios have purchased trucks having all four wheels power-driven.

These portable outfits are built in all sizes from 20 to 100 K.W. capacities. In the smaller sizes up to about 25 K.W., some very successful equipments have been built using the chassis of some first class high-powered automobile. In these cases the generator is chain-driven from the automobile engine. A separate clutch being provided so that the generator may be disconnected while the outfit is in transit.

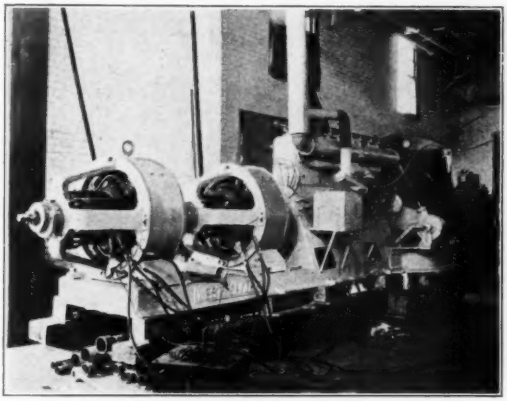
On these small equipments it is, of course, advisable to use pneumatic tires but on the large outfits weighing five to six tons complete, solid tires are most satisfactory.

The switchboard equipment for these portable plants is very simple, consisting of a small panel having mounted thereon, ammeter, voltmeter, automatic carbon circuit breaker, field rheostat, generator switch, and outgoing cable or bus bar terminals. Where two generators are used two single-pole carbon breakers, two pole generator switches, two ammeters, and two field rheostats are employed.

Unfortunately at the time this paper was written none of the large portable plants using Liberty engines had been completed so that it is impossible to show any photographs or results of tests on these sets, but the first of these outfits was being tried out by Marshall Neilan on location in Glacier National Park, Montana.

The first electrical equipment for any studio in Japan was recently sold and consists of:

One 8-cylinder 200 H.P. Winton engine, direct connected to Two 50 K.W. type "SK" Westinghouse generators, all of which are direct connected and mounted on a common base. The radiator



100 K.W. Engine driven generating equipment for Shochiku Kinema Co. of Tokyo, Japan.
200 H.P. Winton engine 8-cylinder, 2 - 50 K.W. Westinghouse Generators, 125 volt.

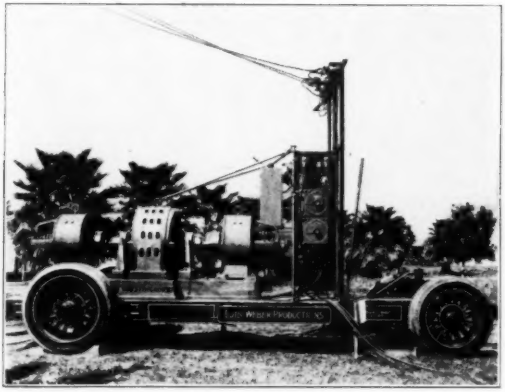
and blower fan are also mounted on the same base and mechanically connected to the engine. While this outfit is not intended for portable purposes, the engineering features are practically identical with a portable outfit.

The electrically driven sets have many points in common with the gasoline driven equipments—they must be easily transported, capable of standing heavy overloads for short periods, and the voltage regulation must be good. From an electrical standpoint, they must be so designed that they can be used on all of the power lines in their home territory at least, and be provided with proper protective devices on the alternating current side. Metering equipment should also be provided for metering the A.C. power used.

Lois Weber Productions have had the 100 K.W. portable electric plant, illustrated below, in use for one year and are greatly pleased with the results. This outfit which is one of the largest and best designed in use at the present time might be described in detail to give you a good idea of these portable electric motor generator sets.

This set is a three-unit, Westinghouse equipment, consisting of a 200 H.P., 3-phase, 2,200-volt, 50-cycle, 6-pole induction motor, direct connected to and mounted on the same base with two 50 K.W., 115-volt, flat compound wound, interpole generators.

On the forward end of the trailer are mounted the switchboards and incoming power line structure. The California State Accident Commission requires that the 2,200-volt connections to the power line must be at least twelve feet above ground, so a telescope pipe frame-



2 - 50 K.W., 120 volt Westinghouse type S.K. Generators.
Portable Motor Generator Set of Lois Weber Productions, Los Angeles, Calif.
1 - 50 P., 3 phase, 2200 volt, 50 cy. Westinghouse motor.

work was designed, which could easily be set up on location and readily taken down while the outfit was in transit.

Mounted on the upper cross-arm of this pipe framework are three high-tension fuse blocks, to which are connected the long flexible leads, used for attaching to the 2,200-volt power lines. The power is then conducted down in conduit to the oil circuit breaker ahead of the auto-starter. This oil circuit breaker provides protection for the motor while the auto-starter is in the starting position The auto-starter is provided with automatic overload and no-voltage protection.

The metering equipment, consisting of the ordinary type of polyphase integrating watt-hour meter, with potential and current transformers, is placed in an enclosed steel cabinet. This meter is tested by the Power Company at certain intervals. In this manner

accuracy is assured and it greatly simplifies matters for both parties by avoiding disputes regarding the power consumed.

In all Southern California it is possible to obtain three-phase, 2,200-volts, 50-cycle power without difficulty, so that all of these portable electrical plants are designed for that voltage on the A.C. end.

The direct current switchboard is also mounted on the forward end of the trailer, the A.C. and D.C. boards facing each other, a space of approximately 30 inches being left as a passage-way for the operator in charge. This direct current-switchboard is standard in every respect. Generally, only one feeder circuit is used so that only a generator panel with a single set of automatic carbon circuit breakers is necessary. Bus bar terminals for the outgoing feeder cables are provided on the rear of the direct current switchboard. All of the wiring is placed in conduit making it safe. The insulating oil used in the 2,200-volt auto-starter and circuit breaker can be drained into a tank under the floor of the trailer and pumped back again by means of a hand pump. This is necessary to prevent the waste of this oil due to splashing while the outfit is in transit.

You will note from the photographs that this layout is neat in appearance, convenient, and safe. When the outfit is not in use on location it is taken into the studio sub-station, where the A.C. and D.C. cables can be connected to it in a few minutes. In this manner, it becomes a very efficient and economical piece of apparatus for the studio.

While the gasoline-driven plant might prove too expensive to operate in the studio in competition with electric power, it has proven its worth out on the desert or up on a mountain or some other place where the necessity for power lines has not yet arisen. Both the electric and gasoline-driven portable power plants have their place and the fact that all the large western studios have them is convincing proof of their value to the motion picture industry.

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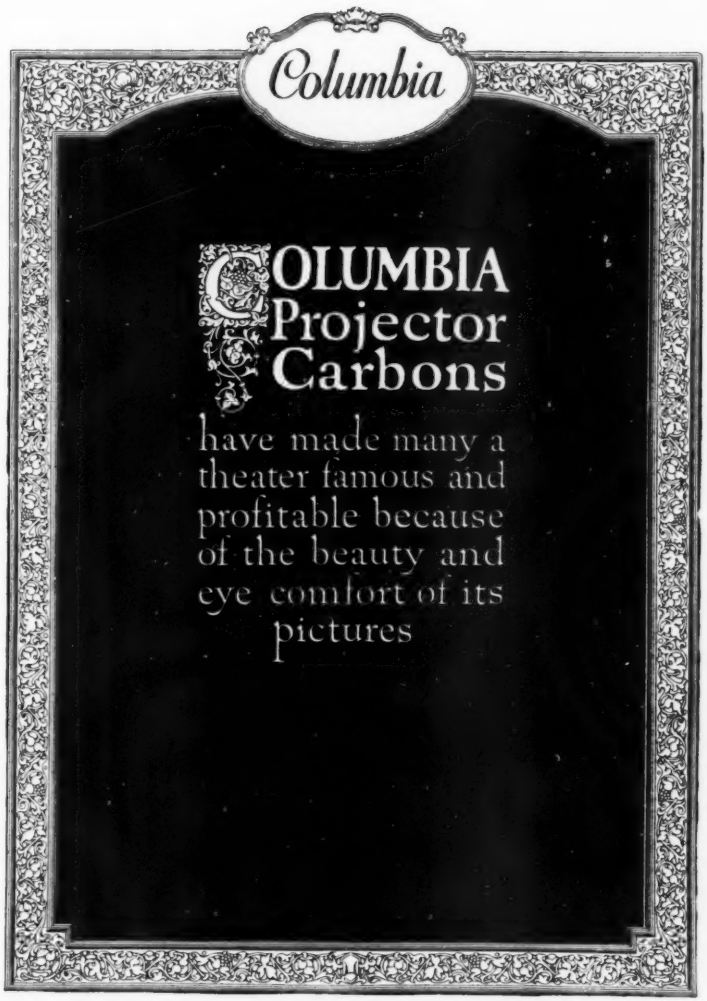
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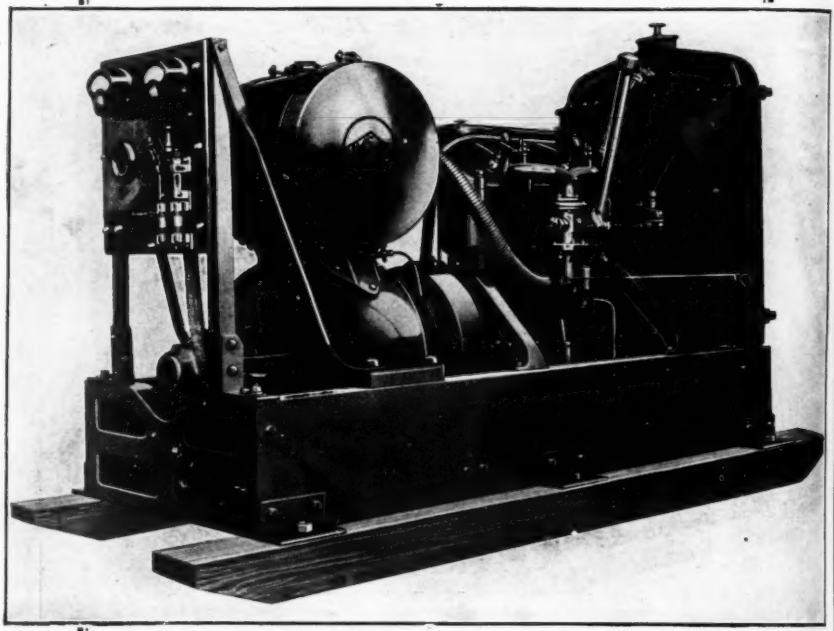

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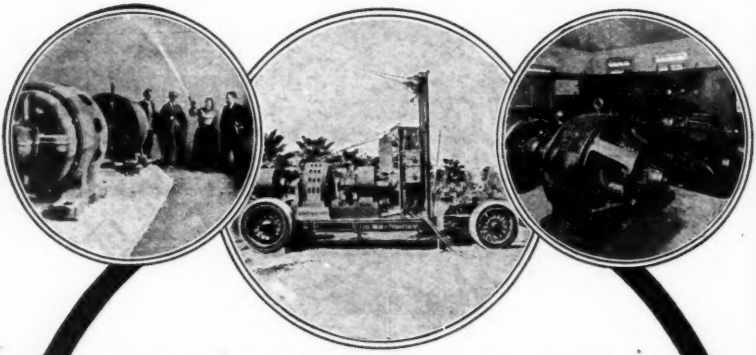

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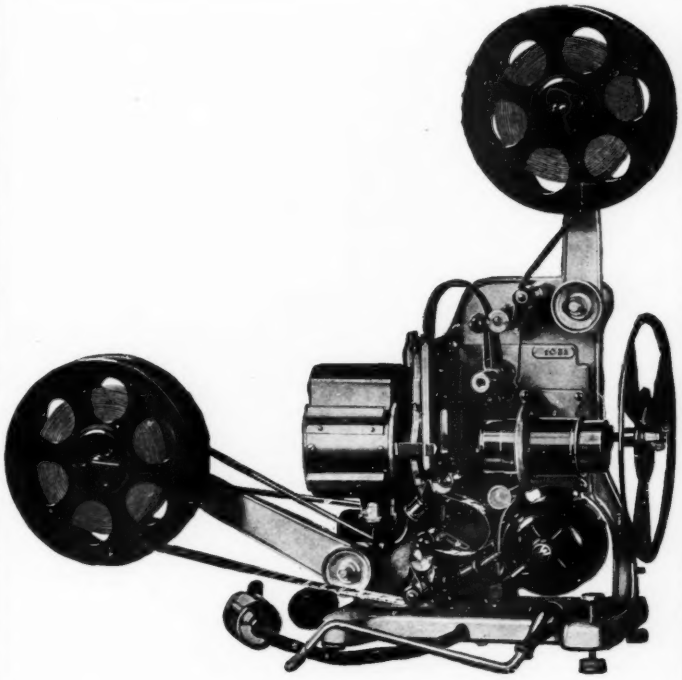

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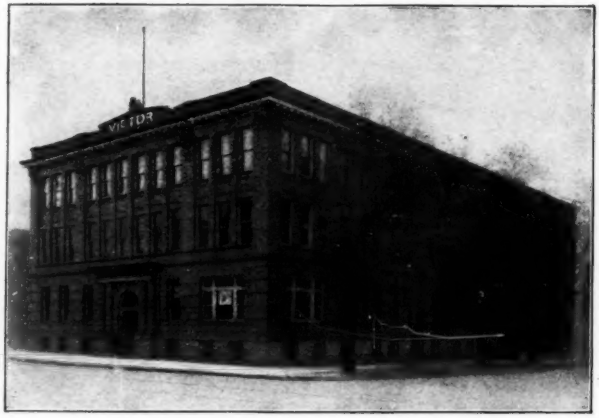

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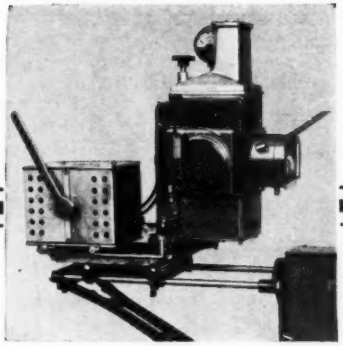

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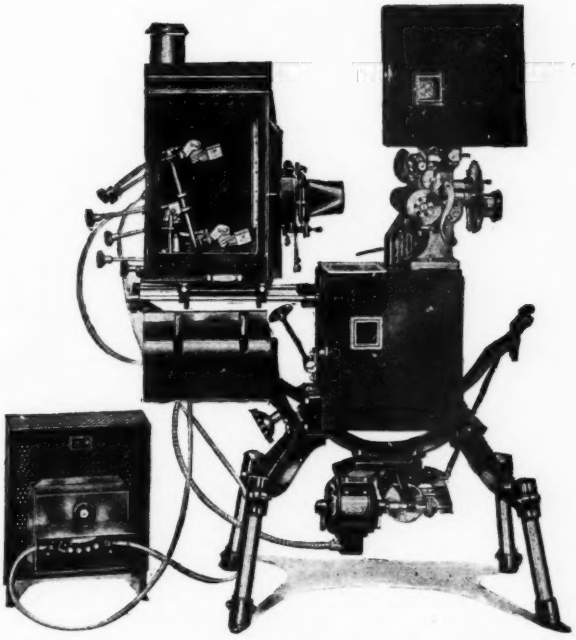

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